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ORIGINAL ARTICLES.

I.—The British Fossil Shrews.

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(PLATE XXV.)

REMAINS of Shrews have long been known to occur in the Norfolk 'Forest Bed', and have been discovered in several British Pleistocene deposits. Hitherto they have been referred to one or other of the three species at present inhabiting this country, but having had occasion lately to examine nearly all the available material, comprising representative series of specimens from each of the known horizons, I find that it is not until we reach the latest Pleistocene deposits that we meet with remains of species indistinguishable, with the material before us, from the living British forms.

The Shrews are low Placentals specialized in two ways, viz., (1) for an insectivorous diet, and (2) to a smaller degree for a subterranean existence. They have been divided into two groups:[1] *Soricinæ*, in which the teeth are more or less extensively stained with a reddish-brown pigment; *Crocidurinæ*, in which the teeth are quite white. All the British species, fossil and recent, so far discovered belong to the first group; and so far as the characters of the fossil forms are known they are all referable to one or other of the two living British genera, *Sorex* and *Neomys*.

Sorex stands on a slightly lower plane than *Neomys* in most respects.[2] It retains one more premolar above; in the large lower incisor three or four of the denticles primitively present upon the crowns of mammalian incisors persist until an advanced stage of wear has been reached[3]; and the condyle of the lower jaw and the glenoid articulation of the skull, although differing much from the normal mammalian type, are a little less highly modified. In the small size of most of the species, their external characters, and the form of the skull and humerus, we see the effects of an adaptation to life underground.

[1] Dobson, Proc. Zool. Soc., 1890, p. 49. Winge suggested this classification many years before (*Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, p. 138).

[2] The best account of the skull of the Shrews and of their relationships is to be found in the following works of Winge: "Om Muldvarpens og Spidsmusenes Cranier og Spidsmusenes systematiske Stilling," *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, p. 115; "Om Græske Pattedyr," ibid., 1881 (1882), p. 12; "Pattedyr," *Danmarks Fauna*, 1908, pp. 14–16, 22–7.

[3] Owen, *Anatomy of Vertebrates*, vol. iii, p. 306, 1868.

Neomys has gone a little further, and, in adopting an aquatic habitat, in a different direction, which has to some extent influenced its external characters. A premolar has been lost above; the large lower incisor has been simplified—only one of the primitive denticles, in addition to that forming the point of the tooth, persisting; and the peculiar modification of the mandibular condyle, and the glenoid cup into which it fits, has proceeded further.

The mandible offers good characters for the determination of the fossil species, and of the earlier British forms little more is known. The strange features presented by the articulation of the lower jaw with the skull in the Shrews were first described by Cuvier,[1] and more fully by Winge[2] and Parker.[3] The mandibular condyle bears two facettes, an upper and a lower, widely separated by a non-articular tract of bone, and which correspond with two facettes upon the squamosal. In *Sorex* (Figs. 7*a*–14*a*) the middle non-articular region is as broad as, or broader than, the superior facette, and the lower facette is not prolonged lingually. In *Neomys* the non-articular region is much narrowed, so that it appears on the posterior view of the condyle as a slender rod of bone connecting the two facettes, the lower facette having in addition a great lingual prolongation (Figs. 1*a*–4*a*). In *Sorex* the *foramen ovale* passes forward between the squamosal and alisphenoid, its mouth, wholly concealed by a process of the squamosal, lying internally to and a little below the lower glenoid facette.[4] In *Neomys* the lingual extension of the lower glenoid facette prevents the *foramen ovale* from opening so far forwards; it therefore has its mouth behind the glenoid cup, and is completely visible on the lower view of the skull.[5]

Sorex.

Dental formula: i. $\frac{1.2.3}{1}$ c. $\frac{1}{1}$ p. $\frac{4.3.1}{1}$ m. $\frac{1.2.3}{1.2.3} = 32$.[6] Lower incisor with three or four long persistent denticles. Middle non-articular part of condyle not reduced in breadth, lower condylar

[1] Cuvier, *Leçons d'Anatomie Comparée*, 2nd ed., t. ii, p. 323, 1837.

[2] Winge, *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, pp. 119, 121, etc.

[3] Parker, "On the Structure and Development of the Mammalian Skull."—Part III, Insectivora: Phil. Trans., pt. i, pp. 213–15, pl. xxxi, figs. 3, 3*a*, 10, *cd.p.*, *gl.c.*, 1885.

[4] Parker, op. cit., p. 217, pl. xxxi, figs. 2, 3.

[5] Winge, op. cit., p. 134, fig. 6; Parker, op. cit., p. 217.

[6] Notwithstanding the fact observed by E. Brandt, viz. that the premaxilla holds *four* teeth, I prefer to follow Winge and regard the last of these teeth as the canine, and not as inc. ^{4}—a tooth quite unknown among Placentalia. The premaxilla has grown that it may accommodate the enlarged first incisor, and in so doing it has embraced the vestigial canine. There is nothing more remarkable in this than there is in the fact that the upper incisor of most rodents bursts through the premaxilla behind and attains a seat in the maxilla. The transgression in either case receives a physiological explanation (see Winge, "Jordfundne og Nulevende Pungdyr fra Lagoa Santa," *E Museo Lundii*, ii (11), p. 122, Anm. 39, 1893; *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1881, pp. 12, 13, and 1882, p. 65). I also prefer to write the premolar formula in Hensel's way ("Ueber Hipparion Mediterraneum," *Abhand. königl. Akad. Wiss. Berlin*, 1860, p. 78). From the excessive reduction of the tooth here called p. ^{3} we may infer that the missing tooth in *Sorex* is p. ^{2}.

facette without lingual prolongation, *foramen ovale* not visible on lower view of skull.

The genus occurs in the Forest Bed and later British deposits. With the exception of *S. savini* all the fossil species are small, forms not exceeding *S. araneus* in size.

Sorex savini, n.sp. (Pl. XXV, Figs. 6, 7, and Text-fig. 7*a*.)

Sorex remifer, Owen, *British Fossil Mammals*, 1846, p. 28, fig. 14, No. 3.
S. vulgaris, Newton, *Vertebrata Forest Bed*, 1882, p. 97, pl. xv, figs. 5–8; Woodward & Sherborn, *Cat. Brit. Foss. Vert.*, 1890, p. 382.
"*Sorex*, large species" Newton, op. cit., p. 97, pl. xv, figs. 13, 14.
Crossopus remifer, Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 17, 1885.

[While this paper has been passing through the press the names of the new species (herein fully described for the first time) have been published in Barrett Hamilton's *History of British Mammals*, parts viii and ix, September and November, 1911, pp. 80, 125.]

Material examined.—(1) Two mandibular rami, left and right, the latter the specimen figured by Owen (loc. cit. sup.) from the Upper Freshwater Bed at Ostend (Green Coll., B.M., Nos. 17653 and 15949*a*); (2) two right rami and two fragmentary maxillæ, figured by Newton (loc. cit. sup., pl. xv, figs. 5–8), in the Museum of Practical Geology; (3) seven rami (five with posterior end) and several maxillæ in the Savin Coll. (B.M. 6154 and 6157); (4) fifty-four rami (thirty-eight with posterior end) and several maxillæ in Mr. Savin's private collection; (5) posterior part of a right ramus in my own collection; in addition numerous limb-bones. Excepting the specimens in the Green Collection the whole of this material was obtained from the Upper Freshwater Bed at West Runton.

Characters.—Size large (the dimensions of the remains of this and other species are given in the tables of measurements at the end). Mandible (Figs. 6, 7, 7*a*): coronoid process large and stout, its upper border broad and round, its outer surface having posteriorly a well-marked and extensive fossa for insertion of the tendon of the lower part of the temporal muscle and fibres from the separate horizontal muscular band which runs below the temporal; condyle very massive. Teeth stained deeply from summit to external cingulum; the latter well developed. Incisor (seen in seven jaws) as in recent *Sorex*, with four denticles and three notches in moderately worn specimens—the two posterior notches are the deeper ones. Skull: known at present only from maxillary fragments; posterior border of infra-orbital canal above front edge of m. ^{1}; lachrymal foramen over middle of m. ^{1}. Two specimens (S.C. B.M. 6157 and S.C. 637.5 [1]) show that there were five unicuspid teeth as in recent *Sorex*. Two specimens (S.C. B.M. 6157 and S.C. 637.7) have the three posterior unicuspids in place and one or more are seen in several other fragments. The unicuspids decrease in size regularly from before backwards as in *S. minutus* and *S. alpinus*; p. ^{3} projects beyond cingulum of p. ^{4}, it is entirely visible externally and, although

[1] 'S.C. B.M.' means 'Savin Collection, British Museum'; 'S.C.' means the more recently formed private collection of Mr. Savin.

shorter antero-posteriorly, a little wider than either p. ^{4} or the canine. Cheek-teeth (p. ^{1}–m. ^{3}) essentially as in recent *Sorex*; posterior emarginations of first three (p. ^{1}–m. ^{2}) considerably shallower than in *S. araneus*—a feature well seen in Newton's figures (op. cit., pl. xv, figs. 5, 6).

The larger limb-bones from the Forest Bed are clearly referable to *S. savini*. The humerus (five complete examples before me) differs importantly from that of *S. araneus* in that the ridges for the insertion of the pectoral, deltoid, and *teres major* muscles descend to a much lower point upon the shaft (*vide* Newton's figure, op. cit., pl. xv, fig. 14). Length of humerus, 9.2–10.1 mm.

Remarks.—Science owes much to Mr. Savin's careful collecting from the Forest Bed, and personally I am indebted to him for the extreme liberality with which he has placed his material at my disposal. I have therefore great pleasure in naming this fine Forest Bed species in his honour. *S. savini* is distinguished as the largest British Shrew hitherto discovered, and it is only known from the Upper Freshwater Bed.

SOREX RUNTONENSIS, n.sp. (Pl. XXV, Figs. 8, 9, and Text-fig. 8*a*.)

Crossopus fodiens, Owen, *Brit. Foss. Mam.*, 1846, p. 28, fig. 14, No. 1; Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 17, 1885.
Sorex pygmæus, Newton (in part), *Vert. For. Bed*, p. 97, pl. xv, fig. 11, 1882.

Material examined.—Mandibulæ: (1) two left rami from Upper Freshwater Bed, Ostend (Green Coll., B.M. 17653*a* and 15949), the first specimen being that figured by Owen (loc. cit. sup.) and referred by him to *Crossopus fodiens*—the characters of the condyle and incisor clearly show it to be referable to *Sorex* and not *Neomys*; (2) two rami in the Museum of Practical Geology, of which one was figured by Newton (loc. cit. sup.); (3) a left ramus in Savin Coll. (B.M. 6154); (4) thirty-two rami in Mr. Savin's private collection. All the specimens enumerated have either the condyle or else the incisor in place; all come from the Upper Freshwater Bed, and, excepting the two in the Green Collection, from West Runton.

Characters.—Size small, but considerably larger than *S. minutus*. Mandible (Figs. 8, 8*a*, 9): coronoid process slender and pointed above; condyle very light, its vertical diameter conspicuously less than the antero-posterior length of ascending ramus at level of molars. Incisor when unworn with four denticles and three notches, the two posterior notches persisting until an advanced stage of wear. Teeth stained extensively.

Remarks.—When determining remains of Shrews from the Forest Bed there cannot be any confusion between those appertaining to the species here named *S. runtonensis* and those of the far larger and very different *S. savini*. In size the lower jaw of *S. runtonensis* is intermediate between those of *S. araneus* and *S. minutus*, and it is distinguished from either by the form of the coronoid process, condyle, etc., as will be best appreciated from the figures and measurements. *S. runtonensis* is known only from the Upper Freshwater Bed.

SOREX sp. (Pl. XXV, Fig. 10, and Text-fig. 10*a*.)

Sorex vulgaris, Hinton & Kennard (in part), *Essex Naturalist*, vol. xi, p. 349, 1900.

Among the Shrew remains collected by Mr. Kennard and the writer from the Middle Terrace brickearth of Grays Thurrock are a posterior half of a left ramus, several still more fragmentary rami, and some imperfect humeri of a species of *Sorex*. In size this Middle Terrace form is smaller than *S. araneus*, the difference being quite noticeable in the lower jaw and still more marked in the humeri. The posterior end of the jaw (Figs. 10, 10*a*) offers some differences in the form of the coronoid process and condyle. The fossa for the insertion of the lower part of the temporal muscle, etc., on the outer surface of coronoid process, is absolutely larger than it is in the bigger jaw of *S. araneus*; the superior articular facette is reduced transversely. The teeth have a weak cingulum externally; the staining appears to have been quite weak because little trace of it can be seen in the only moderately worn teeth of the figured specimen, although the colour is well preserved in the teeth of the species of *Neomys* occurring in the same deposit.

I have no doubt that this Middle Terrace Shrew is distinct specifically from any of the other forms described in this paper. I refrain from naming it because the material is so scanty.

SOREX KENNARDI, n.sp. (Pl. XXV, Fig. 11, and Text-fig. 11*a*.)

Material examined.—Anterior part of a skull and both mandibular rami of one individual from the Third Terrace drift of the Lea Valley at Ponders End, Middlesex.

Characters.—Size distinctly smaller than *S. araneus*, larger than *S. minutus*. Apart from its smaller size there is little to distinguish what is left of the skull from that of *S. araneus*; the mesopterygoid fossa is proportionately broader, and does not narrow behind. The incisors and unicuspids have unfortunately dropped out, but the alveoli show that the latter were five in number, and, apparently, that they decreased in size regularly from before backwards as in *S. alpinus* and *S. minutus*, and not in rough pairs as in *S. araneus*. The cheek-teeth, p. $\frac{1}{4}$–m. $\frac{2}{3}$, have the posterior emargination less deep than in *S. araneus*. The mandible (Figs. 11, 11*a*) is distinguished by its form and size; condyle agrees better with *S. minutus* and *S. alpinus* in form than with *S. araneus*.

Remarks.—We owe the discovery of the specimen here described to the keen eye of Mr. A. S. Kennard, who obtained it on the occasion of a visit of the Geologists' Association to the very important section at Ponders End.[1] I am unable to refer it to any known species, and have great pleasure in naming this form after my friend, to whom I am indebted in so many ways.

[1] Warren, *Nature*, vol. lxxxv, p. 206, 1910; Proc. Geol. Assoc., vol. xxii, p. 168, 1911.

SOREX ARANEUS, Linn. (Pl. XXV, Fig. 12, and Text-fig. 12*a*.)

Sorex araneus, Linnæus, *Systema Natura*, x, 53, 1758.

S. vulgaris, Linnæus and most recent authors; Woodward & Sherborn, *Cat. Brit. Foss. Vert.*, 1890, p. 382 (Kent's Hole and Teesdale Caverns; material not seen by me); Newton, Q.J.G.S., vol. l, p. 192, pl. xi, fig. 1, 1894 (Ightham Fissures); Jackson, *Lancashire Naturalist*, 1910 (Dog Holes, Warton Crag).

S. araneus, Dorothea Bate, GEOL. MAG., Dec. IV, Vol. VIII, p. 103, 1901 (Wye Cave; material not seen by me).

Material examined.—Fossil: (1) three nearly perfect and more than a score of fragmentary skulls and numerous mandibulæ from the Ightham Fissures (in the collections of Dr. Frank Corner and myself); (2) one perfect and several fragmentary skulls and many mandibulæ from the Dog Holes Cave, Warton Crag, in the British Museum (presented by Mr. J. W. Jackson); (3) six fragmentary skulls and a left ramus from the submerged forest at Leasowe (B.M. M. 7593); (4) a left ramus from the Holocene of Worm's Heath (B.M., presented by Mr. R. H. Chandler). I have studied this material with skulls of twenty-eight recent specimens of *S. araneus* in my own collection, from West Wickham and Ightham in Kent, Wanstead, Essex, and West Runton, Norfolk.

Remarks.—Ightham Fissures: The three nearly perfect skulls of which the dimensions are given in Table I are a trifle smaller than are those of recent *S. araneus*, but among the fragmentary specimens there are many larger ones; forty-one mandibulæ were carefully measured (results summarized in Table II), and give a range of variation similar to that of the recent specimens. I am unable to distinguish these remains from *S. araneus*. Dog Holes: The perfect skull is remarkable for the great breadth of brain-case; the lower jaws (twelve measured) agree with those of *S. araneus*. Two others, with lengths of 8·9 and 9·1 mm., may indicate the presence of *S. kennardi* in this cave, but more material is required. Leasowe and Worm's Heath (Holocene): The remains from these deposits are referable to *S. araneus*, and call for no comment.

S. araneus is not known from any deposit in Britain of greater antiquity than the latest part of the Pleistocene period.

SOREX MINUTUS, Linn. (Pl. XXV, Fig. 14, and Text-fig. 14*a*.)

Sorex minutus, Linnæus, *Systema Naturæ*, xii, 73, 1766.

S. pygmæus, Laxmann, *Sibirische Briefe*, lxxij (ed. Schlözer, 1769); Newton, Q.J.G.S., vol. l, p. 192, pl. xi, fig. 2, 1894 (Ightham Fissures).

Material examined.—Four rami from the Ightham Fissures in the collection of Dr. Frank Corner.

Remarks.—As will be seen from the measurements, these specimens agree in size with the mandibulæ of this species, to which they appear to be referable.

NEOMYS.

Neomys, Kaup, *System der Europäischen Thierwelt*, vol. i, p. 117, 1829.

Crossopus, Wagler, Oken's *Isis* (Jena), 1832, p. 275, and most subsequent authors.

Dental formula: i. $\frac{1}{1}\frac{1.2.3}{}$ c. $\frac{1}{1}$ p. $\frac{4}{}\frac{.}{}\frac{1}{1}$ m. $\frac{1.2.3}{1.2.3} = 30$. Lower incisor with one persistent denticle. Middle non-articular part of condyle

reduced in breadth; lower condylar facette with extensive lingual prolongation; *foramen ovale* visible on lower view of shell. The genus is represented in the Upper Pliocene Forest Bed and later British deposits by species none of which exceed the living *N. fodiens* in size.

NEOMYS NEWTONI, n.sp. (Pl. XXV, Fig. 1, and Text-fig. 1*a*.)

Sorex pygmæus, Newton (in part), *Vert. For. Bed*, 1882, p. 97, pl. xv, fig. 12.

Material examined.—Mandibulæ: (1) left ramus in Museum of Practical Geology figured by Newton (*loc. cit. sup.*); (2) two right rami in British Museum (Savin Coll., M. 6154); (3) twenty-six rami in Mr. Savin's private collection; (4) two in my own collection. All these specimens were obtained from the Upper Freshwater Bed at West Runton; all of them have the condyle and one has the incisor in place.

Characters.—Size smaller than *Neomys fodiens*. Apart from its small size the mandible (Figs. 1, 1*a*) differs in form from that of the living Water Shrew; the coronoid process is relatively lower. The condyle viewed from behind is of extreme form, the non-articular part being greatly reduced in breadth; its superior facette reaches proportionately further back than in *N. fodiens*. The humerus figured by Newton (op. cit., pl. xv, fig. 9) is, in all probability, referable to this form.

Remarks.—I have named this species *N. newtoni* in honour of Mr. E. T. Newton, F.R.S., to whom we owe so much of our knowledge of the Forest Bed vertebrata. The species is known only to occur in the Upper Freshwater Bed, and it does not require any close comparison with other forms.

NEOMYS BROWNI, n.sp. (Pl. XXV, Fig. 2, and Text-fig. 2*a*.)

Sorex? sp. non det., Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 16, 1885.
S. vulgaris, Hinton & Kennard (in part), *Essex Naturalist*, vol. xi, p. 349, 1900.

Material examined.—Mandibulæ: (1) posterior half of a left ramus from the brickearth of Grays Thurrock (Middle Terrace), in the British Museum (No. 28079, presented by John Brown); (2) part of a right ramus with m. $\frac{1 \text{ and } 2}{}$ in place, from the same deposit, in the Hinton and Kennard Collection.

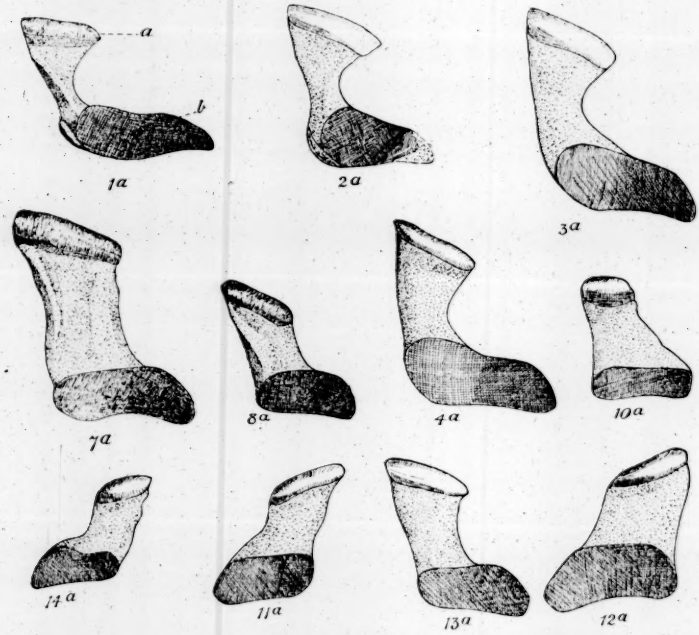
Characters.—Mandible a little smaller than that of *N. fodiens*; its coronoid process low and broad; condyle small, its vertical dimension very small for a *Neomys*, and the superior facette very broad (Figs. 2, 2*a*). Teeth a little smaller than in *N. fodiens*; their outer cusps stained nearly to cingulum; cingulum strongly developed.

Remarks.—This species is named after the late John Brown of Stanway, a careful observer, who discovered and presented the type jaw to the National Collection. *N. browni* is a very distinctive form, recalling *N. newtoni* in the low coronoid process, but differing from all other species in the form of the condyle. It is only known from the Middle Terrace drift of the Thames at Grays.

NEOMYS FODIENS, Schreber.
(Pl. XXV, Figs. 3–5, and Text-figs. 3*a*, 4*a*.)

Sorex fodiens, Schreber, *Die Säugethiere*, vol. iii, p. 571, 1777.
Neomys fodiens, Dorothea Bate, GEOL. MAG., Dec. IV; Vol. VIII, p. 104, 1901 (Wye Cave).

Material examined.—(1) Four mandibular rami (three, including one perfect one, in the Corner Coll., one in Hinton Coll.) from the Ightham Fissures; (2) a left ramus from the Dog Holes Cave, Warton Crag, in the British Museum (presented by Mr. J. W. Jackson); (3) parts of two skulls and a right ramus from the submerged forest of Leasowe (B.M. M. 7593).



Posterior views of condyles of fossil Shrews.

Remarks.—Miss Dorothea Bate has referred "an upper jaw . . . which still retained its full number of teeth", which she found in the Wye Cave, to this species (GEOL. MAG., Dec. IV, Vol. VIII, p. 104). With this exception all the previous records of *Neomys fodiens* in a fossil state in Britain appear to have been founded on error.

Late Pleistocene: Ightham Fissures and Dog Holes. The mandibulæ (Figs. 3, 3*a*, 4, 4*a*) from these deposits have the coronoid process a little lower relatively than in recent jaws of *N. fodiens*, and the condyle appears to be a trifle larger in proportion. They may belong to a distinct form, but with the scanty material before me I should not be justified in separating them from *N. fodiens*.

Holocene: Leasowe. The remains from this deposit agree perfectly with recent *N. fodiens*.

TABLE I. MEASUREMENTS[1] (IN MILLIMETRES) OF SKULLS OF FOSSIL AND RECENT SPECIES OF *SOREX*.

	Sorex araneus.										*Sorex kennardi.*	*Sorex alpinus*, Transylvania. Recent.	*Sorex minutus*, Clevedon. Recent.
	Pleistocene.				Recent.								
	Ightham Fissures, Corner Collection.			Dog Holes, Warton Crag.	Ightham, Kent.			West Runton, Norfolk.					
	(1)	(2)	(3)		(1)	(2)	(3)	(1)	(2)	(3)			
1. Extreme length to front edge of premaxillaries	18·7	18	19·1	18·4	19·0	19·4	19·7	19·4	19·3	19·0	—	19·4	15·3
2. Greatest width of brain-case . . .	8·9	—	—	9·7	9·1	9·8	9·6	9·7	9·7	9·6	—	9·5	7·3
3. Interorbital breadth	3·7	3·6	3·8	3·5	3·7	3·7	3·8	3·8	4·0	3·5	3·2	4·2	2·8
4. Malar breadth	5·28	4·95	5·28	5·17	5·28	5·39	5·39	5·39	5·39	5·39	4·62	5·17	4·07
5. Length of cheek-teeth (i.e. p. ^{4} – m. ^{3})	4·51	4·4	4·62	4·51	4·62	4·62	4·73	4·51	4·62	4·73	4·18	4·4	3·63
6. Length of tooth row, excluding inc. ^{1}	6·82	6·6	7·26	6·82	7·26	7·26	7·48	7·26	7·15	7·26	5·94	7·04	5·5
Reduction 1 = 100	100	100	100	100	100	100	100	100	100	100	—	100	100
2 =	47·6	—	—	52·8	47·9	50·6	48·7	50·8	50·3	50·6	—	49	47·7
3 =	19·8	20	19·9	19·0	19·5	19·1	19·3	19·9	20·7	18·5	—	21·7	18·3
4 =	28·2	27·5	27·7	28·1	27·8	27·8	27·4	28·2	27·9	28·4	—	26·6	26·6
5 =	24·1	24·4	24·2	24·6	24·3	23·9	24	23·6	23·9	24·9	—	22·7	23·7
6 =	36·5	36·7	38	37·1	38·2	37·4	38	38	37·1	38·2	—	36·3	36·0

[1] The dimensions 4, 5, and 6 of Table I and all those of Table II, with the exception of the length of the lower jaw, were measured with an eyepiece micrometer and 5 inch objective.

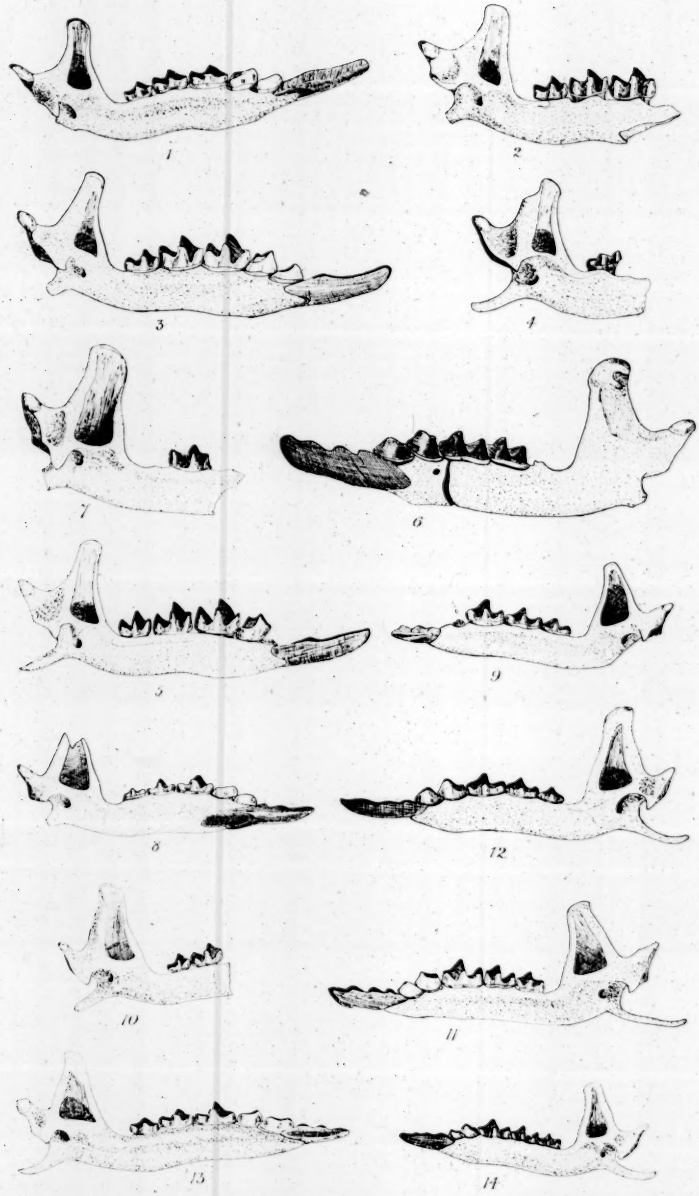
TABLE II. MANDIBULÆ OF FOSSIL AND RECENT SPECIES OF *SOREX* AND *NEOMYS*.

	Length, condyle to most anterior point on bone, inner side.	Length of tooth row, excluding incisor $_1$.	Length of molars (m. $_1$ to $_3$).	Height of coronoid process.	Width of coronoid process, condyle to anterior margin.	Height of jaw, inner side, below m. $_2$.
A. SOREX:						
Sorex savini	11·8	6·05	4·07	5·61	3·74	1·65
	12·0	—	—	5·72	3·85	1·71
S. runtonensis. Fig. 8, Sav. Coll. 731.8	9·0	4·73	3·41	—	2·64	1·32
,, Fig. 9, Sav. Coll. 636.15[1]	8·9	4·73	3·74	3·74	2·64	1·21
S. sp. Middle Terrace, Grays	—	—	—	4·4	2·75	1·32
S. kennardi. Third Terrace, Ponders End	9·0	4·78	3·41	3·85	2·64	1·21
S. araneus. Pleistocene, Ightham Fissures	10·3	5·5	3·85	4·84	3·08	1·54
	9·7	5·06	3·52	4·4	2·75	1·48
,, ,, Dog Holes, Warton Crag	10	5·5	3·85	4·4	3·08	1·32
	9·4	5·06	3·57	4·4	2·75	1·32
,, Recent, Ightham	10	5·5	3·85	4·73	3·19	1·48
,, ,, West Wickham	10·4	5·5	3·85	4·51	3·08	1·43
	9·7	5·28	3·63	4·51	2·97	1·54
,, ,, Wanstead	9·7	5·28	3·63	4·51	2·97	1·32
,, ,, West Runton	9·9	5·28	3·74	4·62	3·19	1·32
S. alpinus. Hatzeg, Transylvania	10·1	5·39	3·63	3·74	2·64	1·32
S. minutus. Pleistocene, Ightham Fissures	7·6	4·07	2·97	2·97	1·98	0·77
	7·4	4·18	2·97	3·0	2·09	0·77
,, Recent, Clevedon, Somerset	7·3	4·07	3·13	3·13	2·2	0·99
B. NEOMYS.						
Neomys newtoni. Upper Freshwater Bed, West Runton	10·4	5·61	3·85	4·07	2·86	1·54
N. browni. Middle Terrace, Grays	—	—	4·29	4·29	2·97	1·54
N. fodiens. Pleistocene, Ightham	10·9	6·16	4·4	4·34	2·86	1·37
,, ,, Dog Holes	10·1	—	4·29	4·18	2·75	1·43
,, Recent, West Wickham	11·0	6·16	4·34	4·56	3·08	1·65
,, *naias*. Recent. Transylvania	11·4	6·38	4·4	4·73	3·19	1·43

The following scheme shows the range in time in Britain of the various Shrews discussed in this paper:—

HORIZON.		SPECIES.
HOLOCENE		*Sorex araneus*, *S. minutus*, *Neomys fodiens*.
PLEISTOCENE	*a*. Ightham Fissures, etc.	*Sorex araneus*, *S. minutus*, *Neomys fodiens*.
	b. Third Terrace	*Sorex kennardi*.
	c. Early Middle Terrace, Grays	*Sorex* sp., *Neomys browni*.
LATEST PLIOCENE	Upper Freshwater Bed (Forest Bed Series)	*Sorex savini*, *S. runtonensis*, *Neomys newtoni*.

[1] This specimen is remarkable for the unusually large true molars.



M. A. C. Hinton del.

JAWS OF BRITISH FOSSIL SHREWS.

It will thus be seen that so far as our knowledge of the fossil Shrews goes they promise to support, when better known, the classification of the Pleistocene deposits which I put forward in my preliminary account of the Voles and Lemmings. *Sorex araneus* and *Neomys fodiens* do not inhabit Ireland, although *S. minutus* is found there. All three were present in Britain in the closing stages of the Pleistocene period; it may be that *S. minutus* arrived a little earlier than its two larger relatives, or it may have been a little better adapted for so adventurous an enterprise as a late Pleistocene journey to Ireland. In conclusion, I have to thank many friends, and in particular Mr. A. C. Savin and Dr. Frank Corner, for much fossil and recent material.

COMBINED EXPLANATION OF LOWER JAWS, PLATE XXV, AND TEXT-FIGURES OF CONDYLES OF SHREWS.

a = superior, *b* = inferior articular facette of mandible.

Fig.

1. *Neomys newtoni*, Hinton. Inner view of left ramus; 1*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Savin private collection, No. 631.5.
2. *N. browni*, Hinton. Inner view of left ramus; 2*a*, posterior view of condyle. Pleistocene, Grays Thurrock. B.M. 28079.
3. *N. fodiens* (?), Schr. Inner view of left ramus; 3*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Corner Coll.
4. *N. fodiens* (?), Schr. Inner view of left ramus; 4*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Hinton Coll.
5. *N. fodiens* (?), Schr. Inner view of left ramus. Pleistocene, Dog Holes, Warton Crag. B.M., Jackson Collection.
6. *Sorex savini*, Hinton. Outer view of left ramus. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 731.10.
7. *S. savini*, Hinton. Inner view of left ramus; 7*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Hinton Coll.
8. *S. runtonensis*, Hinton. Inner view of left ramus; 8*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 731.8.
9. *S. runtonensis*, Hinton. Inner view of right ramus. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 636.15.
10. *Sorex* sp. Inner view of left ramus; 10*a*, posterior view of condyle. Pleistocene, Grays Thurrock. Hinton and Kennard Coll.
11. *S. kennardi*, Hinton. Inner view of right ramus; 11*a*, posterior view of condyle. Pleistocene, Ponders End.
12. *S. araneus*, Linn. Inner view of right ramus; 12*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Hinton Coll.
13. *S. alpinus*, Schinz. Inner view of left ramus; 13*a*, posterior view of condyle. Recent, Hatzeg, Transylvania. B.M., No. 3.11.8.12.
14. *S. minutus*, Linn. Inner view of right ramus; 14*a*, posterior view of condyle. Recent, Clevedon, Somerset. Hinton Coll.

II.—The Unconformable Relationship of the Lower Tertiaries and Upper Cretaceous of New Zealand.

By Professor James Park, F.G.S.

WITH the question of conformity or unconformity between the Lower Tertiary and Upper Cretaceous, there is associated a problem of great economic importance to New Zealand. The

[1] Hinton, Proc. Geol. Assoc., vol. xxi, p. 497, 1910.

subject involves something more than a mere academic discussion. If conformity exists, then we have only one coal-bearing formation; but if unconformity, then we have two. I believe that both the stratigraphical and palæontological evidence is overwhelmingly in favour of the latter.

In volume xliii of the Transactions of the New Zealand Institute, Dr. P. Marshall and Messrs. R. Speight and C. A. Cotton in a paper on the "Younger Rock Series of New Zealand" express the view that there is no stratigraphical break from the Cretaceous to the Pliocene, a contention mainly based on their interpretation of the Waipara section in North Canterbury. This section, be it noted, was responsible for the adoption of the Cretaceo-Tertiary theory by the old Geological Survey under Sir James Hector. A better knowledge of the geology of the country showed that this position was untenable. As time went on, and fresh discovery took place, it became more and more evident that the so-called Cretaceo-Tertiary succession consisted of two distinct unconformable series, the one with a distinctively Tertiary fauna, the other with an equally distinctive Cretaceous fauna.

While the theory lasted it led to many incorrect correlations of distant beds. Clayey beds, for example, found below the Ototara Stone were everywhere called Amuri Limestone; greensands containing 20 per cent of living forms were correlated with sandy beds yielding Saurians, Belemnites, etc.; and the term Grey Marls was applied to any grey sandy bed in contact with the Weka Pass Stone.

The confusion introduced by the Cretaceo-Tertiary theory soon became an almost inextricable tangle, on all fours with the famous Cretaceo-Eocene tumble of the Laramie, where it was found that the confusion arose through the erroneous correlation of horizons in distant places, afterwards proved by closer examination to belong to two distinct formations, namely an Upper Cretaceous and a Lower Tertiary.

The time-worn Cretaceo-Tertiary theory of New Zealand was first abandoned by its sponsor, Captain Hutton, then by Professor Cox, and afterwards by myself. For over twenty years it has found no defender or exponent among the field geologists of the country, and, moreover, it was not recognized in the new classification of formations drawn up for the new Geological Survey.

The confusion arose (*a*) through the coincidence that the successions of strata in the Lower Tertiary and Upper Cretaceous formations bear a general lithological resemblance to one another; (*b*) that at Waipara the Tertiary Series seemed to be conformable to the Cretaceous Series.

The Lower Tertiary Series, best known as the Oamaru Series, occurs as a dissected marginal sheet in both islands, while the Cretaceous, or Waipara Series, is restricted to a few isolated patches in each island. The Tertiary Series almost everywhere rests on the highly denuded surfaces of Jurassic or older rocks. In a few places only does it touch the Cretaceous Series.

Both the Tertiary and Cretaceous Series represent a complete cycle of deposition during subsidence, each beginning with fluviatile drifts,

with which are associated seams of brown coal, fireclays, and other terrestrial deposits, and ending with a bed of marine limestone.

The Tertiary Series is extensively developed in both islands, and wherever it is found all the members are present from the highest to the lowest bed, except in North Canterbury, where the basal coal beds are absent. Unfortunately there is only one place where all the members of the Cretaceous succession are known to be present, and that is at Waipara.

The succession of the Lower Tertiary Series at Waihao, South Canterbury, which may be taken as typical, and of the Cretaceous Series as seen at Waipara, are shown below in tabulated form:—

Lower Tertiary (Oamaru Series).	Upper Cretaceous (Waipara Series).
1. Limestone (Ototara Stone). Soft coralline, sandy.	1. Limestone (Weka Pass Stone). Hard, crystalline.
2. Greensands, with Tertiary fauna.	2. Grey chalky limestone with Ammonites (Amuri Limestone).
3. Sandy beds and sandstones, with Tertiary marine shells in great abundance, with 20–5 per cent of living species.	3. Greensands, with *Belemnites*, etc.
4. Conglomerate, shales, and brown coal.	4. Sandy beds, with septarian concretions containing Saurian remains, etc.
	5. Conglomerate, shales, and brown coal.

In the days of the Cretaceo-Tertiary theory the Weka Pass Stone was believed to be the equivalent of the Ototara Stone, and this was responsible for much of the confusion, for according to this view the Weka Pass Stone was conformably underlain by beds that in one place contained a purely Cretaceous fauna and in others a purely Tertiary fauna, including a number of living species. It was more puzzling still that the Tertiary facies appeared all over New Zealand while the Cretaceous was confined to a few isolated patches. Moreover, there was never any mingling of the faunas. These anomalies created constant misgivings in the minds of those most wedded to the theory, with the result that many hypotheses were examined and fully discussed by the field-geologists of the Survey, but all were rejected as untenable.

While still in the belief that there was one and not two series, we frankly recognized that we were faced with an apparently insoluble problem in the failure of the Tertiary fauna to invade the few isolated patches occupied by the Waipara Series. The Tertiary fauna had found time to spread from one end of New Zealand to another, therefore slowness of migration could not be entertained as a satisfactory explanation.

I will now examine the evidences of unconformity as presented at Shag Point, Northern Otago, Waipara in North Canterbury, and Komiti Point, North Auckland.

Shag Point District.—In this district we have a good development of both the Lower Tertiary and Cretaceous Series lying side by side in actual juxtaposition. The whole of the Tertiary Series is present from the calcareous sandstone (Waikouaiti or Ototara Stone) down to the basal conglomerates, while all the members of the Cretaceous Series are present except the higher members, namely the Amura Limestone and Weka Pass Stone.

The Cretaceous Series rests on a highly denuded surface of the Palæozoic mica-schist. The Tertiary Series also rests on the mica-schist and abuts against the various members of the Cretaceous Series.

The Tertiary beds extend northward from Waikouaiti to the Shag River, occupying the floor of the Lower Shag Valley, which is wide and low-lying. The beds are nearly horizontal or dip towards the sea at angles between 3° and 5°. Their succession has been determined by bore-holes and outcrop exposures.

The Cretaceous Series forms the steep ridges on the north side of the Lower Shag Valley. Its basal conglomerates and coal-measures are tilted at high angles, and, going eastward to the sea, are folded as shown in Fig. 1.

The upper beds (No. 1) contain *Belemnites lindsayi*, and Saurian bones form the nucleus of many of the septarian boulders, many of which attain a diameter exceeding five feet. Beds No. 2 contain *Conchothyra parasitica*, *Trigonia*, *Rostellaria*. The Cretaceous facies of these beds has never been disputed.

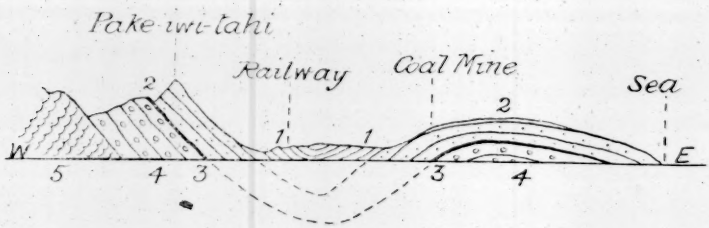


Fig. 1. (1) Dark greensands passing down into shaly clays and sandstones with numerous septarian boulders; (2) brown sandstones alternating with gritstones and pebbly beds; (3) gritstones, loose sands, and grits, with shales and coal-seams; (4) conglomerates, mainly quartzose, passing into mica-schist breccia at base; (5) mica-schist.

The nearly horizontal Tertiary strata, on the other hand, that abut against the tilted and folded Cretaceous Series contain only the typical Lower Tertiary fauna of the Oamaru Series. Moreover, the large septarian concretions that are so characteristic of the Cretaceous beds are absent. The thickness of the tilted and folded Cretaceous strata is 2,200 feet, and of the adjoining horizontal Tertiaries 1,200 feet.

Sir James Hector, in 1862, before the Cretaceo-Tertiary theory was thought of, in a beautiful coloured geological map of North Otago, now in the Otago University School of Mines, showed the horizontal Tertiaries resting unconformably on the Shag Point Cretaceous Series as they are seen to do in the field. This relationship is shown in Fig. 2.

The authors state that the unconformity shown in my section (*Geology of New Zealand*, p. 116) is a matter of inference, as no outcrops could be found in the estuary. This was apparently an oversight on their part as the Tertiary rocks form the low banks of a branch of the Shag River near the mouth, well within the influence of the tidal flow.

The complete succession of the two series is given below—

Lower Tertiary.	Upper Cretaceous.
1. Calcareous sandstone (Ototara Stone).	1. Greensands.
2. Greensands.	2. Shales and sandstones, with septarian concretions.
3. Blue clays.	3. Brown sandstones, gritstones, and pebbly beds.
4. Soft dirty-grey sandstones.	4. Gritstones, loose sands, and grits with shales and seams of brown coal.
5. Quartzose conglomerate, shales, and brown coal.	5. Quartzose conglomerates, passing down into breccias. Bed-rock = mica-schist.

The total thickness of the Tertiary basal conglomerate is about 300 feet, and of Cretaceous basal conglomerates about 1,500 feet.

The Cretaceous age of the Shag Point Series has always been admitted, but according to the Cretaceo-Tertiary theory this series is the horizontal equivalent of the adjoining Shag Valley–Waikouaiti

Fig. 2, showing relationship of Lower Tertiaries to Shag Point Cretaceous Series. 1 and 2, Cretaceous beds; 3, calcareous sandstone (Waikouaiti or Ototara Stone), with *Pseudamusium huttoni*, *Meoma crawfordi*, etc., as seen in north bank of Shag River, opposite Pake-iwi-tahi Cairn, where subject to tidal influence.

Series, which contains the typical Lower Tertiary fauna of the Oamaru Series. Here we have the Cretaceous (Waipara) Series and the Lower Tertiary (Oamaru) Series lying side by side. The Cretaceous rests on the mica-schist, and the Tertiary on both the schist and the various members of the Cretaceous.

Professor Cox when a supporter of the Cretaceous theory examined Shag Point, and seeing the difficulty of correlating the two series with one another, suggested the existence of a fault on the north side of the Lower Shag Valley, along the boundary of the two series. Of this fault there is no structural evidence whatever, but, even if it does exist, it merely serves to emphasize the unconformity between the two series, for if the fault is meant to imply that the Tertiary Series followed the Cretaceous Series conformably, and has been merely faulted down into its present position in the Shag Valley, then obviously in the faulted portion we should expect to find the Cretaceous Series underlying the Tertiary Series, but as a matter of fact the Tertiaries rest hard on the mica-schist and wrap round the edges of the Cretaceous.

Mr. A. G. MacDonald, B.E., Government Research Scholar for Otago, has just completed a detailed geological survey of the Shag

Point District. His work of many months in this limited area shows no evidence of faulting, and seems to prove the unconformable relationship of the Cretaceous and Tertiary formations beyond all possible doubt. Moreover, it is almost certain that the tilting and folding of the Cretaceous Series took place before the deposition of the Tertiaries; for it is inconceivable that the younger series could have escaped the folding movement that subjected the older to such sharp disturbance.

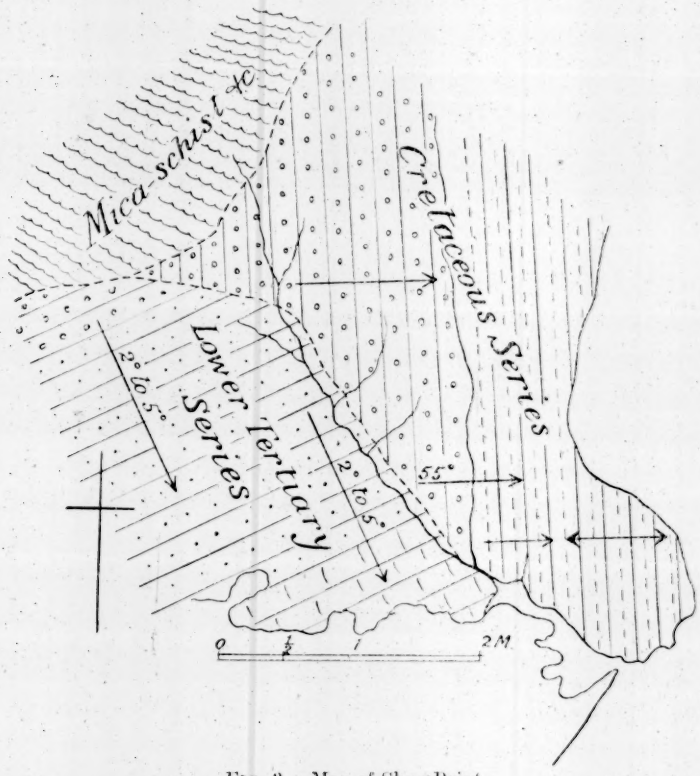


FIG. 3. Map of Shag Point.

Kaitangata District.—Here, as at Shag Point, we have both Lower Tertiary and Cretaceous strata, which, according to the Cretaceo-Tertiary theory, are supposed to be horizontal equivalents. The Kaitangata Cretaceous Coal Series rests on the schists, and the Tertiary Series on both the schists and Kaitangata Series. No actual contact of the Cretaceous rocks and Tertiaries is anywhere exposed, the juncture being obscured by a thick sheet of glacial detritus. But the distribution as shown by the very exact mapping lately carried out by Mr. A. G. MacDonald, the marked difference in the character of the strata, and the palæontological evidence seem to leave only one conclusion possible.

The Tertiary sequence is almost identical with that found in other parts of New Zealand, being as follows:—

TERTIARY SERIES.

	Feet.
1. Limestones	125
2. Greensands	125
3. Brown and grey sandstones	460
4. Quartzose sands, grits, and conglomerates, with seam of brown coal	260

The thickness of the whole series is about 970 feet.

The characteristic fossils of the Upper Oamaruian are abundant, including *Pseudamusium huttoni*, *Cirsotrema browni*, *Meoma crawfordi*, and *Kekenodon onemata*. The Cretaceous rocks are represented by only the lower members of the Waipara Series, as follows:—

1. Sandstones and shales. 2. Greywacke conglomerates, with shales and seams of brown coal, one 35 feet and one 18 feet.	Kaitangata Upper Coal-measures.
3. Brown sandstones and shales. 4. Sandstones, with calcareous layers; fossiliferous. 5. Quartzose sands, bands of conglomerate and shales, with seams of brown coal.	Kaitangata Lower Coal-measures (Castle Hill and Taratu Coals).

The total thickness of these beds is about 1,450 feet, as compared with the 260 feet of the corresponding Coal-measures of the Tertiary Series. Moreover, the great bands of greywacke conglomerate, so conspicuous in the Kaitangatas, are unrepresented in the Tertiary Series.

The Tertiary Series contains only Tertiary forms; but the fossiliferous sandstones of the Kaitangata lower measures contain, among numerous well-preserved fossils, *Belemnites lindsayi*, *Cucullæa alta*, *Conchothyra parasitica*, and *Rostellaria*, forms which connect these beds with the Cretaceous Shag Point and Waipara formations.

Relationship of Waitemata Series to North Auckland Coal Series.—The North Auckland Coal Series consists of the following members:—

1. Sandstones.
2. Hydraulic limestones.
3. Greensands, with septarian boulders.
4. Semi-crystalline limestone.
5. Soft sandstones and shales, with seams of pitch coal.
6. Conglomerates and sandstones.

The septarian concretions that occur in the greensands are covered with an exterior skin of cone-in-cone limestone, and frequently enclose Saurian bones. The Cretaceous age of this series is not in doubt.

The Tertiary Waitemata Series is now acknowledged by all geologists to belong to the Oamaruian, a relationship based on the strongest palæontological grounds.

In my examination of the Auckland district in 1885, I found blocks of the hydraulic limestone in the Lower Waitematas near Howick and Onehunga, and the following year discovered on the coast near Wade a beautiful section showing the Waitemata resting unconformably on the Cretaceous rocks.

At Komiti Point the Tertiary Series contains a large assemblage of fossils, the majority of which are found in the Waitematas, Mount Brown, and Kakanui Beds. When reporting on these beds I placed them in the Upper Eocene,[1] and there is no reason to doubt their relationship to the Waitemata and Oamaru formations. At Komiti Point the Tertiaries rest on the highly denuded edges of the hydraulic limestone, as seen in a very clear section exposed in the sea-cliffs. These observations, it should be noted, merely confirmed the opinion previously expressed by Professor Cox and Mr. McKay that the older Tertiaries were unconformable to the Cretaceous Coal Series.

Waipara District.—In the district there is a complete development of the Cretaceous Series from the Weka Pass Stone down to the basal conglomerates containing brown coal, as under:—

1. Weka Pass Stone.
2. Amuri Limestone, with Ammonites.
3. Greensands.
4. Sand and shaly clays, with septarian boulders containing Saurian remains, *Conchothyra parasitica*, etc.
5. Grits, conglomerates, and shales, with bands of impure brown coal.

The Lower Tertiary Series is well developed, but the lowest member, the Brown Coal-measures, is absent. When viewed in

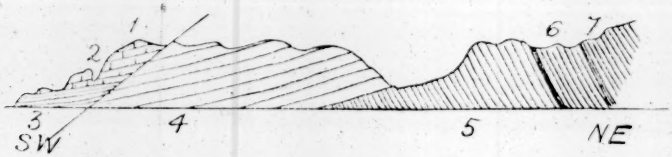


FIG. 4. Section at Komiti Point, showing unconformable relationship of Lower Tertiaries and Cretaceous Coal Series. 1–4, Lower Tertiaries; 5–7, shales and chalky clays passing into hydraulic limestone.

cross-section the Tertiary beds appear to follow the Weka Pass Stone conformably. The members of the Tertiaries present are—

1. Calcareous sandstone bands (Mount Brown or Mount Donald Beds).
2. Greensands.
3. Dirty greyish sandstones.
4. Absent (conglomerate, shales, and brown coal).

The failure at first to recognize the absence of the basal grits and conglomerates of the series arose from the erroneous correlation of the Ototara Stone with the Weka Pass Stone, the Cretaceous Series with its Saurians and other Mesozoic forms being supposed in the old Cretaceo-Tertiary days to be the horizontal equivalent of the Oamaru Tertiary Series.

According to this correlation, the Ototara Stone lay conformably on Cretaceous strata at Waipara, and conformably on Tertiary strata in a hundred other places both north and south of Waipara. Now the Ototara Stone is the most persistent member of the Lower Tertiary Series throughout New Zealand. According to its distance from the old shore-line it is a sandy, sometimes pebbly, calcareous sandstone

[1] Geol. Reports, 1885, pp. 164–9.

that passes into a compact shelly limestone in a few places. It is everywhere fossiliferous generally, and its characteristic fossils from one end of New Zealand to the other are *Pseudamusium huttoni*, which is never known to be absent, *Cirsotrema browni*, and *Meoma crawfordi*.

The Weka Pass Stone, on the other hand, has never yielded any recognizable fossils, the fossils reported to have been found in it by Haast having been, as I showed in 1904 (Trans. N.Z. Inst., vol. xxxvii, p. 545), obtained from blocks of fossiliferous stone that had tumbled down from the overhanging escarpments of the Tertiary beds on Mount Donald, and lodged on the Weka Pass Stone outcrops.

The authors, however, do not follow the old Geological Survey, but correlate the Oamaru Stone with the Amuri Limestone, and the Weka Pass Stone with the Hutchinson Quarry Beds. I may say that the most enthusiastic supporter of the supposed Cretaceo-Tertiary never ventured so far as to correlate the Oamaru Stone with the Amuri Limestone. The Oamaru Stone everywhere contains a large assemblage of Tertiary fossils, and is admitted to overlie conformably beds that contain from 20 to 28 per cent of living forms. How, then, can it be the equivalent of the Amuri Limestone, which has yielded no fossils except an Ammonite, and which, moreover, is admitted by all observers to overlie conformably beds that contain a large assemblage of Mesozoic Saurians, *Belemnites*, *Conchothyra*, etc.? The suggested correlation has no more foundation than, say, the correlation of the Barton Sands of Hampshire with the Lower Chalk of the North and South Downs. Their correlation of the Hutchinson Quarry Beds with the Weka Pass Stone is supported by no evidence or any attempt to analyse the position.

Now the Weka Pass Stone contains no known fossils, whereas the Hutchinson Quarry Beds contain a fauna rich in forms, of which over 40 per cent are present in the Mount Donald or Mount Brown Beds, which overlie the Weka Pass Stone by many hundred feet. Why, then, correlate the Hutchinson Quarry Beds with the Weka Pass Stone, which contains none of the Hutchinson Quarry fossils, when there is an overlying horizon (Mount Donald) in the same section, which contains so many of them?

In 1904[1] and in my work on the *Geology of New Zealand*, 1910, I correlated the Otatara Stone with the Mount Brown and Mount Donald Beds on the grounds that a very large number of the distinctive fossils was common to both horizons. The Oamaru and Waipara districts are separated by 150 miles, and I should not care to assert that any particular bed at Oamaru was deposited on the same time-plane as some particular portion of the Mount Brown Beds, but I think the similarity of the faunas is so striking that there can be little doubt we are dealing with two closely related series.

The following is a list of nineteen of the more abundant fossils in the Ototara Stone at Oamaru and Mount Brown Beds at Waipara,

[1] Park, "Marine Tertiaries of Otago and Canterbury": Trans. N.Z. Inst., vol. xxxvii, pp. 489–550, 1904.

regarding the two calcareous bands at Kakanui as local extensions of the latter:—

Ototara Stone, common also to the Mount Brown Beds.	
Kekenodon onemata.	*Pseudamusium huttoni.*
Aturia australis.	*Lima paleata.*
Dentalium mantelli.	*Plagiostoma lævigata.*
Scaphella corrugata.	*Cucullæa alta.*
Siphonalia nodosa.	*Venericardia awamoaensis.*
Cirsotrema browni.	*Magellania novara.*
Ostrea angasi.	*M. parki.*
Anomia alectus.	*Terebratula oamarutica.*
Pecten hutchinsoni.	*Meoma crawfordi.*
P. williamsoni.	

About 46 per cent of the faunas are common. Moreover, *Cirsotrema browni*, *Pseudamusium huttoni*, and *Meoma crawfordi* are characteristic of the Ototara Stone horizon from one end of New Zealand to the other.

The Mount Brown Beds at Waipara contain besides these many forms that are only found *below* the Ototara Stone in the Oamaru district. In fact, the Mount Brown fauna is perhaps nearer that of the Wharekuri sands lying below the Ototara Stone than any other horizon in New Zealand, no less than 50 per cent of its fossils being common to both. It would thus happen that in correlating the Mount Brown Beds with the Ototara Stone instead of a lower horizon, as the palæontological evidence would seem to warrant, I have pursued a conservative course.

Discussing the age of the Oamaru Stone, the authors state that they believe it to be Oligocene, a European refinement of age which our present knowledge of the Tertiary faunas does not justify. But let us suppose for the moment that it is Oligocene as suggested. The Oamaru Stone is, they tell us, the equivalent of the Amuri Limestone, which is by all admitted to lie conformably on the greensands and sandy beds containing Mesozoic Saurians, *Belemnites*, etc. Here, then, we get the curious phenomenon of an Oligocene limestone lying conformably on an Upper Cretaceous formation.

In my report on the Wanganui-King County in 1886–7 I stated that there appeared to be a complete succession from the new Pliocene down to the basal conglomerates of the Lower Tertiary Coal Series. No stratigraphical break was recognized in the Tertiary succession. The unconformity which I thought I recognized at Waipara between the Mount Brown and Motanau Beds may not exist, or if it does it may be purely local. In my classification of the Jamger formations adopted in my *Geology of New Zealand* I have recognized only one physical break, namely one between the Oamaru and Waipara Series. Nothing that I have seen since the publication of that work has led me to alter the opinion I then expressed. Moreover, the evidence is overwhelming that we have two great coal-bearing formations in New Zealand, namely—

1. Oamaru Series . . Lower Tertiary.
2. Waipara Series . . Upper Cretaceous.

The authors state that the new Geological Survey under Dr. Bell did not find it practicable to divide the younger rock series into two or

more systems. So far as the Lower Tertiaries and Upper Cretaceous are concerned the reason for this is obvious. Of all the areas covered by the Bulletins issued by the new Survey, in the Kaeo district alone (Bulletin No. 8) were the Lower Tertiary and Upper Cretaceous formations present. In their report on this district Dr. Bell and Mr. E. de E. Clarke took particular pains to point out the obscurity of the sections, and after discussing the situation go on to say[1]: "It will be seen that in the Whangaroa subdivision the sum-total favours the view that the Kaeo Series should be divided into an older portion of Mesozoic age and a younger portion of Tertiary age, or, in other words, that a Cretaceo-Tertiary system is not represented."

A classification of the New Zealand formations was drawn up in 1907 for the Geological Survey by Dr. Bell, the Director, Mr. A. McKay, some time Government Geologist, and myself; and although this classification was recognized as a compromise that did not exactly express the views of any one of us on all points, it did not find room for a Cretaceo-Tertiary succession, the Lower Tertiary and Upper Cretaceous being placed in two separate systems, that is in the Oamaru and Waipara systems respectively. Moreover, I have good authority for saying that the present Director, Mr. Percy G. Morgan, does not recognize a Cretaceo-Tertiary system. The fact is that while flagrant unconformity may exist between two formations, places may be found where deceptive physical conformity may exist, as so well shown by Professor Watts in his *Geology*, fig. 153, p. 221.

The differences that exist between the views of Hutton, myself, and others as to the Waipara section cannot be regarded as proof of a complete succession, but are rather suggestive of the difficulty that had to be faced in the interpretation of a section that seemed to be so opposed to the palæontological evidence.

A fine succession of the Upper Cretaceous is exposed at Amuri Bluff, but as no Lower Tertiary rocks are known there the relationship cannot be established between the two systems in that district.

III.—Upper Cretaceous Terebelloids from England.

By Dr. F. A. Bather, M.A., F.R.S., F.G.S., etc.

(*Concluded from p. 487.*)

Tubes without extraneous Building Material.

Davies referred to *Terebella* (?) *lewesiensis* four specimens said by him to be in the J. R. Capron Collection, purchased for the British Museum in 1879. "Two casts from a quarry near Guildford," he wrote, "which admirably show by impression the membranous or horny structure of the tube, bear no indication of the attachment of any foreign substance." The quarry is Cowslip Pit, near Guildford, and the Chalk appears to be Cenomanian, possibly of the *Holaster subglobosus* zone. The two specimens are believed, on the evidence of Davies' labels, to be those now registered A 1574 and A 1575. "These," continues Davies, "may be referred to the same species

[1] J. M. Bell & E. de E. Clarke, "The Geology of the Whangaroa Subdivision": Bulletin No. 8, N.S., p. 58.

upon the evidence of a third fragment from the same quarry, which has precisely the same surface structure, but has also some scales attached and faint impressions of others." There are in the Capron Collection, among the specimens from Cowslip Pit, three other tubes with the same surface structure as A 1574 and A 1575, namely, A 1576, A 1577, and A 1582; but none of these three has any scales attached or any markings that I can identify as impressions of scales. There is no other specimen of the kind from Cowslip Pit, so that I am unable to identify the "third fragment" of Davies. It is possible that he had in mind another specimen, also from the Capron Collection, but labelled "Glynde", Sussex [58253]; since, near one end of this, there are in the chalk a few fish-scales. This specimen was, in fact, labelled "*Terebella lewesiensis*" by Davies, but the evidence that the fish-scales had anything to do with the tube is not convincing.

A fourth specimen was called as witness by Davies because he believed it to retain "deep imprints of the lost scales and bones". This, if it came from Cowslip Pit as alleged, must have been one of the three mentioned above; but there seems no reason for distinguishing any one of those as more deeply marked than the others, nor do the markings on any resemble the imprints of scales. In ordinary specimens of *Terebella lewesiensis* it is quite easy to see the places from which scales or bones have been knocked off, and there is no difficulty in discriminating between such imprints and the surface ornament of the tubes here in question. Tubes like A 1574/5 are quite common in the Cenomanian, and first aroused my curiosity in the *Actinocamax plenus* zone of Chilcomb Pit, near Winchester, some thirty years ago; but I have never seen any in obvious connexion with fish-scales.

The only specimen that seems to me to lend any support to the view of Davies is one to which, oddly enough, he made no reference, although it was before him in the Mantell Collection [B.M. 4129]. This tube is sharply bent so as to form two limbs, one of which seems to sink into the chalk. This limb, 7 cm. long, is flattened out to a diameter of 24 mm., and is covered with scales and small bones. The other limb, which lies on the surface of the block for a length of 10 cm., is rounded, with a diameter of 17 mm.; except for two or three small scales this limb is bare, but its surface presents some irregularly disposed impressions, which may be those of scales or bones. If this specimen be considered without reference to the others, two explanations of its appearance are possible. First, the bare portion may have been buried in the ooze during life, and the protective wall of fish-debris may have been built up round that part alone which projected above the sea-floor. Or secondly, the whole tube may have been furnished with a protective wall, which has been rubbed or washed away from the more exposed limb, but retained on that part of the tube which was longer covered by the matrix. The first explanation would be quite consistent with the habits and structure of some living Tubicola,[1] but scarcely seems to harmonize with what we infer from the other undoubted specimens of *Terebella lewesiensis*. Were this tube normally provided with a 'Vorderbau' and an

[1] See E. Macé, "De la structure du tube des Sabelles": Arch. Zool. Expér., vol. x, Notes, pp. ix–xiv, especially p. x, 1882.

'Innenbau' (to use the expressions of Ehlers), one would expect to find more evidence of the fact in so large a collection. The second explanation presents no serious difficulty, but its correctness could only be estimated by the person who actually found the specimen in the chalk-pit.

It appears, then, that the reference of the naked tubes to *Terebella lewesiensis* rests on quite inadequate proof. Closer examination of these fossils will show that they have characters of their own quite distinct from those of any of the protected tubes.

Although, as every collector of Chalk fossils knows, these naked tubes, or tube-infillings, are quite common, yet there are not many in the national collection. This may, indeed, be due to their very commonness, as well as to the fact that they are generally dismissed as indeterminable 'fucoids'. The following are the only localities and horizons represented:—

Betchworth, Surrey. Albian, Upper Greensand. [A 1638.]
Wetton Vale, Louth, Lincolnshire. Cenomanian, *subglobosus* zone, Totternhoe Stone. [A 1639.]
Glynde, Sussex. Cenomanian, ?*subglobosus* zone. [58253.]
Cowslip Pit, near Guildford, Surrey. Cenomanian, ?*subglobosus* zone. [A 1574–A 1577, A 1582.]

It is clear that none of these specimens is complete. The greatest length attained is 19 cm. [A 1574].

Some of the specimens are fairly straight. This might be expected in the shorter lengths, but it is also rather notably the case in A 1638, with a length of 16·5 cm. Others are bent or slightly sinuous; thus 58253 is bent into two limbs, 5·5 and 6 cm. long, and has a length of 10 cm. along the chord.

In diameter there is not much difference between different parts of the tube, but A 1576 tapers slightly. The section when clearly seen is elliptical, and in the following list both diameters are given: 10 and 5 mm. [A 1582, A 1575]; 15 and 12 mm. [58253]; 15 mm. [A 1574]; 17 mm. [A 1639]; 17 and 12 mm. [A 1577]; 20 mm. [A 1576]; 20 and 17 mm. [A 1638]. The last specimen is from the Upper Greensand, so that, so far as the Cenomanian specimens are concerned, it is clear that their normal maximum diameter is considerably less than that of the fish-debris and plant-debris tubes.

The surface-ornament of these tubes, though faint and often obscure, seems to be of definite character. It may be roughly described as cancellate, since the surface, if viewed from a distance under oblique lighting, shows a number of slight depressions arranged in fairly regular transverse and longitudinal rows. Closer examination suggests that the appearance is due to a system of transverse folds or waves, crossed by larger and less regular longitudinal folds. Both systems of folds are clearly seen in 58253, A 1638, and rather less clearly in A 1582. The longitudinal folds are particularly clear in A 1574 (Fig. 5). The transverse folds are seen plainly in A 1577 and A 1576, and less plainly in A 1575; in these and in most other cases where they are observed the transverse folds seem to run in curves, forming a succession of widely open V's (Fig. 4). In A 1639, however, from the Totternhoe Stone, the transverse folds, so far as seen, go almost straight round the

tube. All this ornament is simply a surface appearance; there does not as a rule seem to be any definite tube-wall.

Some specimens, however [e.g. A 1577, A 1582], show, in addition to the cancellar ornament, a fine-grained linear striation crossing the tube at an angle of about 45° (Fig. 4). This seems to be of semi-crystalline nature like the structure usually known as 'beef'. It is presumably due to a physico-chemical action of the supposed gelatinous tube on the surrounding ooze. In A 1582 the striæ run from left downwards to right, but in A 1577 from left upwards to right.

The Upper Greensand specimen [A 1638] is the only one in which I have noted anything suggestive of an original tube-wall. Here in places there seems to be a thin coating of darker, denser, fine-grained (or crypto-crystalline) rock, but it is very indefinite.

The ornament just described forms an additional reason for refusing to assign these tubes to *Terebella lewesiensis* without far more convincing evidence than that adduced by Davies.

What these fossils may be is a different question which would be better discussed by one more fully acquainted with the possible living organisms than I am, and after examination of far more material than is as yet at my disposal.

Specimen A 1638, collected from the Upper Greensand of Betchworth by the donor, Mr. G. E. Dibley, has been referred to by him as "an unusually large Baculite" (Proc. Geol. Assoc., vol. xxi, p. 485, Aug., 1910). To this conception of the specimen he was doubtless led by the peculiar curvature of the strongly marked transverse folds in some regions. Mr. G. C. Crick, however, does not claim it for this or any other kind of Cephalopod.

These and similar fossils from the Chalk are usually called 'fucoids'. How any imaginable fucoid, or any other form of vegetable growth, can have resulted in a fossil of this description has never been clear to me; but, since Dr. Stopes declines to include them in her Catalogue of Cretaceous Plants, any who still believe in their fucoid nature may be left to argue the matter with her.

It seems quite certain that these fossils represent tubes, which lay on the sea-floor or in the semi-floating ooze of which it consisted, and, either being deserted by the creature that formed them or persisting after its death and decay, were filled with the ooze in which they lay. The tube-wall, it is clear, was of such strength and consistency as to retain its form fairly well during this process, and yet of such composition that it disappeared after the partial consolidation of the ooze. The markings on the infilling of the tube may be due to two causes; either a similar folding of the tube-wall during life, or a wrinkling and contraction of the tube after death and perhaps even after burial. The relative regularity, constancy, and peculiar curvature of the transverse folds suggest that they were originally present in the tube, and that they may have been connected with the ringed structure of the tube-builder. On the other hand, the irregularity and very varying development of the longitudinal folds suggest that they, at least, were due to post-mortem changes.

From the Cretaceous beds of the European Continent, and notably from the Flysch, a large number of supposed fucoids have been

described. They were studied and classified in 1897 by Professor A. Rothpletz in his valuable paper "Ueber die Flysch-Fucoiden und einige andere fossile Algen" (Zeitschr. deutsch. Geol. Gesell., vol. xlviii, pp. 854–914, pls. xxii–xxiv). More recently Dr. Otto M. Reis (January, 1910, "Zur Fucoidenfrage," Jahrb. k.k. Geol. Reichsanst., lix, pp. 615–38, pl. xvii) has attempted, and I think with much success, to prove that a number of these Flysch 'fucoids' are the tubes of Terebelloid Tubicola. He seems to regard most of them as having been built up of clay in the same way as the tube of the living *Terebella figulus*. If such genera as *Granularia*, *Squamularia*, and *Keckia* are really based on tubes with a wall capable of being explained in this way, then our specimens are not referable to any of those genera.

For the present the British Museum does not possess enough examples of the numerous strange forms so ably discussed by Rothpletz, Th. Fuchs, O. Reis, and others [1] for any comparison to be made, or for any understanding of the many generic names that have been proposed. To those names I have no intention of adding another.

It has, however, been urged that, for convenience of reference, some name is required for these tubes. Since they have been called '*Terebella*', they may continue to be so called, strictly without prejudice, and may be distinguished as

'*Terebella*' *cancellata*, n.sp. (Pl. XXIV, Figs. 3–5.)

Diagnosis.—Tube from which the (? gelatinous or mucinous) wall has disappeared, leaving on the internal cast an obscure cancellate ornament formed by transverse and longitudinal folds; with diameter from about ·75 to 2 cm., and with a possible length of 19 cm. or more.

Horizon.—Cenomanian, so far as recorded.

Locality.—East and South-East England generally, so far as recorded.

Holotype.—B.M. 58253, from Glynde, Sussex (Fig. 3).

It will be observed that I definitely exclude the Upper Greensand specimen A 1638, which may be known for the present as '*Terebella*' cf. *cancellata*.

Tubes made of Mud Bricks.

Keckia (?) sp. (Pl. XXIV, Fig. 1.)

Associated in the national collection with the series of *Terebella lewesiensis* is another tube labelled "Terebella?, Chalk. Mantell Colln. [4784.]". This is in a greyish, slightly rust-stained chalk, doubtless of Lower Cenomanian age, from South-East England. The specimen is unlike any other in the Museum.

The tube is 7·2 cm. long, slightly flexuous, with a diameter of about 6·5 mm. It appears to have had a distinct wall (now in part broken away) composed of bricks or tiles fashioned from the chalk ooze and laid in a series of imbricating whorls. A spiral arrangement of the whorls is not to be detected, but each appears to have passed

[1] See references in my note "Some Fossil Annelid Burrows", Geol. Mag., March, 1910, pp. 114–16.

straight round the tube. Whether each whorl was composed of several tiles or only of one, continuous all round, is uncertain. The length of a tile was about 6·5 mm., and of this the distal 3 mm. overlapped the next whorl.

The substance of the tiles does not seem to differ in any definite way from that of either the surrounding matrix or the infilling of the tube. Their surface, however, has occasionally a striated 'beefy' appearance.

It is clear that this fossil accords with the interpretation that Dr. O. Reis has given of the Flysch fossils mentioned above. So far as one can follow the descriptions in the absence of material, it seems to approach most nearly the forms classed by Rothpletz (1897) under *Keckia*. "Hierunter verstehen wir die stielförmigen und dichotom verzweigten Fucoiden, welche in Folge von Quereinschnürungen wie aus einer Reihe von Ringen zusammengesetzt erscheinen. Je nach Erhaltungszustand erscheinen diese Ringwülste auch schuppen- oder scheideförmig. Das Genus ist von [E. F.] Glocker 1840 [i.e. 1844] (Acta Acad. Leop. Carol., xix [Suppl., Bd. ii, p. 319]) für eine Art aus dem Karpathensandstein Mährens . . . aufgestellt worden, die er als [*Keckia*] *annulata* bezeichnete." The chief difficulty lies in the words 'dichotom verzweigten'. Glocker's elaborately coloured plate iv does in fact represent a much-branched structure. Of course, our specimen might be a single branch of a branching tube, but I greatly doubt it. However, for the sake of having a name, it may be left in *Keckia* for the present.

Granularia (?) sp. (Pl. XXIV, Fig. 2.)

A small piece of Gault clay [B.M. 39453], from Folkestone, Kent, 7 cm. by 5·7 cm. in area, is strewn with several fragments of tubes composed of granules or pellets. This was bought from Edward Charlesworth about 1860, and was entered in the register of the Geological Department as "'oviform bodies', qy. worm castings". Of late years it has been placed on exhibition under the generic name "*Sabella* (?)". On the other hand, there can be no doubt that the specimen agrees in general character with several usually regarded as 'fucoids' and placed under some such name as *Granularia*. These facts show that the palæontologists of the British Museum were more than prepared to accept the conclusions so lucidly drawn by Dr. Reis (1910).

The tubes are much like those from the Upper Cretaceous Alberese, figured by Reis (pl. xvii, fig. 1) under the name *Granularia lumbricoides*, Heer; stouter and coarser than those figured by Rothpletz (1897, pl. xxii, figs. 8, 9) under the same name; and most precisely represented by the drawings of *Phymatoderma cælatum*, Saporta (1873, Paléont. Franç., Plantes Jurassiques, tome i, p. 472, pl. lxviii, figs. 3, 3*a*).

The direction of the tubes is approximately parallel to the shorter axis of the Gault slab. They are in rather short fragments, the longest being about 22 mm., with an impression showing that it once reached a length of fully 36 mm. The diameter is about 2·5 mm. Over the whole specimen there is no evidence whatever that any of the tubes

branched, although an artist would not need much imagination to represent them as having done so. Saporta both describes and figures his species as "pourvus çà et là d'une ramification solitaire", and this, if well founded, constitutes a clear difference.

The tubes are made up of convexly rounded pellets, brownish in colour, and apparently composed of the minute brownish sand-grains that may be seen with a lens scattered throughout the fine bluish-grey clay of the matrix. The pellets are usually elliptical, with their long axis more or less transverse to the tube.

I do not hesitate to regard these tubes as having been made by such a Tubicolous Annelid as *Terebella figulus* or a *Sabella*; but the question of a name gives rise to much hesitation.

Phymatoderma cælatum, which they so markedly resemble, "s'écarte très-sensiblement, selon nous [Saporta], de toutes les Algues fossiles signalées jusqu'à présent [1873]." This one can understand if it is not an alga but an annelid. But then it would not be a *Phymatoderma*, which appears to have been based by Brongniart on the Liassic *Algacites granulatus* Schlotheim. *P. cælatum* was founded on a specimen from the Oxfordian of Bouches-du-Rhône.

The genus *Granularia* was established by Pomel (1847) with *G. repanda* of Corallian age as genotype. References and details will be found in Saporta (1873, op. cit., p. 108), whose figure of the genotype (pl. xii, fig. 1*a*) shows an obviously branching form. There seems no reason why we should not speak of *Granularia cælata* (Sap.); but our Albian form, though closely resembling that Oxfordian species, is not likely to have been identical. Therefore we may speak of it for the present as *Granularia* cf. *cælata* (Sap.).

To avoid any confusion of the nomenclature, I wish to say quite definitely that I use the names *Keckia*, *Granularia*, etc., only on the supposition that their genotypes, and consequently the genera themselves, are of animal origin. Should those species, with their genera, ultimately be retained among plants, and should the British Cretaceous species here discussed be accepted as Annelida, then no use by me of the names *Keckia*, *Granularia*, etc., is to be regarded as establishing them as new genera of animals.

Summary.

The tubes formed of fish-debris, found throughout the Chalk of England, described by Mantell (1822) as *Muræna* (?) *lewesiensis*, referred by L. Agassiz (1844) to *Dercetis elongatus*, and placed among Annelida Tubicola as *Terebella lewesiensis* by William Davies (1879), are here described with more precise detail and retained in the position assigned to them by Davies. A diagnosis is provided and a holotype selected.

A specimen from the Gault, of similar nature but larger, is made the type of a new species, '*Terebella*' *lutensis* (Fig. 6).

Similar tubes from the Cenomanian, built of Conifer debris and Echinoderm debris, are described, and the question whether these differences of composition indicate a difference of species is discussed, but left open for the evidence of further material. Such tubes may for the present be known as '*Terebella*' cf. *lewesiensis* (Figs. 7, 8).

Tubes without extraneous building material and with a cancellar ornament are also found in the Cretaceous rocks of England, and some were referred to *Terebella lewesiensis* by Davies. All those from the Chalk are here separated as '*Terebella*' *cancellata*, n.sp. (Figs. 3–5).

Two tubes made of mud bricks are discussed. One, apparently of Lower Cenomanian age, is referred to the rather doubtful genus *Keckia* (Fig. 1). The other, from the Gault, is referred to *Granularia* (Fig. 2). Both these genera are held to be of Annelid origin.

IV.—Note on the 'Lower Tremadoc' Rocks of St. David's, Pembrokeshire.[1]

By John Pringle.

In the year 1866 Hicks and Salter recorded[2] the occurrence of certain rocks in the neighbourhood of St. David's which they regarded as Tremadoc deposits. The beds appeared to them to rest conformably on the Lingula Flags, but when the rocks were compared with those of the Tremadoc area striking lithological differences were noticed. Accompanying the report was a list of fossils collected from the beds, and the fauna was so wholly unlike that of the North Wales deposits that the authors were led to conclude that the dissimilarity was due to the conditions under which the strata were deposited.

In 1873 the group was again described by Hicks.[3] In this paper and in a later one[4] the author gave an account of the lithological characters of the rocks, their relation to other formations, and their distribution in the area, describing in his earlier contribution[3] many fossil forms which he regarded as new. Despite the somewhat unsatisfactory conclusions recorded in his joint paper with Salter, Hicks expressed his conviction in the two papers that the strata were Lower Tremadoc.

Since the publication of the last-mentioned memoir, and especially in the light of evidence collected elsewhere, doubts have arisen as to the correctness of Hicks' views. With a hope of clearing up the question of age, the writer was instructed to collect from the group where it is best exposed in the St. David's district, namely, on Ramsey Island and on the mainland at the north end of Whitesand Bay.

Ramsey Island.

The 'Lower Tremadoc' rocks occupy a small area in the north-east corner of Ramsey Island. They form a narrow strip between Ogof Velvet and Bay Ogof Hên (see Sketch-map). They extend for a short distance southwards, but are cut out by a fault

[1] Communicated by permission of the Director of H.M. Geological Survey.

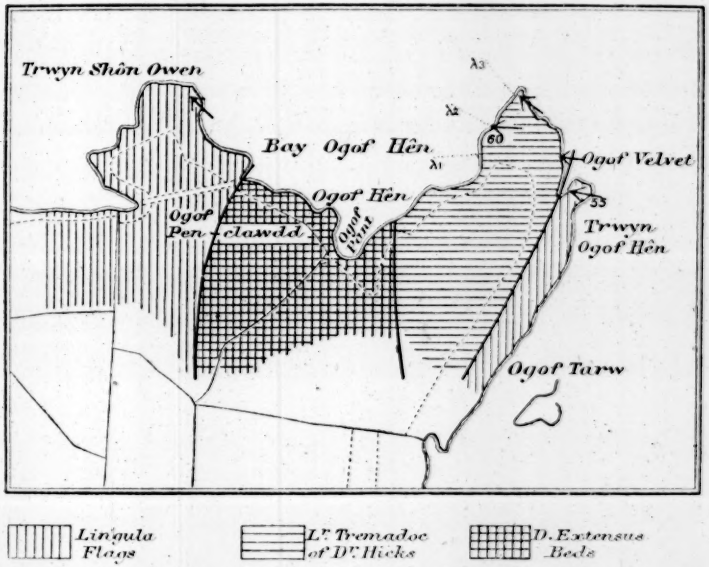
[2] Hicks & Salter, Second Report on the Menevian Group and other formations at St. David's, Pembrokeshire: Rep. Brit. Assoc., Nottingham, 1866, p. 184.

[3] H. Hicks, "On the Tremadoc Rocks in the neighbourhood of St. David's, South Wales, and their fossil contents": Q.J.G.S., vol. xxix, p. 39, 1873.

[4] H. Hicks, "On the Succession of the Ancient Rocks of St. David's": Q.J.G.S., vol. xxxi, p. 167, 1875.

and are brought against shales belonging to the zone of *Didymograptus extensus*. The series is not well exposed inland, but is seen to advantage in the cliff at the north end of the island.

The lowest beds of the group are thin grey sandstones with some shales. Hicks regarded them as forming the base of the 'Tremadoc', and they extend along the foot of the cliff on the west side of Ogof Velvet. They are succeeded by grey sandy shales with thin lenticles of sandstone, and these in turn are overlain by bluish-grey iron-stained mudstones, which are highly fossiliferous. It was from the latter that Hicks obtained his fossils. The strata, which are about 1,000 feet thick, have an average dip of about 60°, and they strike from N.E. to S.W.



Sketch-map[1] of the north-eastern portion of Ramsey Island. Scale, 6 inches to 1 mile. Vertical shading indicates Lingula Flags; horizontal shading indicates Lower Tremadoc of Dr. Hicks; cross-hatching indicates *Didymograptus extensus* beds. Fossil localities shown thus: λ 1, λ 2, etc. Thick lines represent faults.

Hicks and Salter[2] believed that the 'Tremadoc' rested conformably on the Lingula Flags, and that the latter gradually passed upwards into the former group. They were clearly in error, however, as the junction proves to be faulted. The line of dislocation, which runs nearly parallel with the strike, can be seen descending the cliff above Ogof Velvet. The detection of this fault greatly simplified

[1] The line-drawing from which this illustration was prepared was kindly made by Mr. R. Ashborn.

[2] Hicks & Salter, Second Report on the Menevian Group and other formations at St. David's, Pembrokeshire: Rep. Brit. Assoc., Nottingham, 1866, p. 184.

the question of the horizon of the group, and considered with the evidence yielded by the fossils collected at localities λ 1, 2, and 3 (see Sketch-map), it became certain that the beds are of Lower Arenig age.[1] Of the fossils collected the following forms have been identified:—[1]

Orthis calligramma, Dalm., var. *carausi*, Salter.
O. menapiæ, Hicks.
Calymene tristani, Brongn. [*Neseuretus ramseyensis*, Hicks].
Ogygia selwyni (Salter).

The succession of the Arenig rocks at the north end of Ramsey Island is briefly as follows. The lowest beds of the group are a series of thin grey sandstones and sandy shales, which pass upwards into dark-grey iron-stained mudstones which are abundantly fossiliferous. They are faulted against the Lingula Flags at Ogof Velvet, and are not conformable as has been supposed hitherto. A fault on the west side of the fossiliferous mudstones brings the latter against the thin-bedded chocolate-stained shales of the *D. extensus* zone, so that a considerable thickness of shales belonging to the lower part of the zone seen on the mainland at Porth Lleuog, Whitesand Bay, is cut out. The non-occurrence of these shales on Ramsey Island has been previously noted.[2] On the west side of the island the *D. extensus* shales are brought by another dislocation against the Lingula Flags, which form the headland of Trwyn Shôn Owen.

The above succession is similar to that observed in the Arenig rocks in the Carmarthen district,[3] where grits, gritty shales, and conglomerates, associated with a similar fauna, are strongly developed at the base of the shales belonging to the *D. extensus* zone.

Whitesand Bay.

Hicks thought that the lower part of the 'Tremadoc' group was to be seen resting conformably on the Lingula Flags at the north end of Whitesand Bay. He believed the upper members to be cut out by a fault which runs in a north-easterly direction, and brings down Arenig shales on the north side of Trwyn Hwrddyn.

An examination of the section in the light of the results obtained on Ramsey Island convinces me that these rocks do not belong to the group to which they have been assigned. Lithologically, they are inseparable from the Lingula Flags, and the beds which form the promontory of Trwyn Hwrddyn are similar to the flags on the east side of Ogof Velvet. No fossils were obtained except *Lingulella davisi*, which occurs in great abundance.

Further north, at Llanveran, the group is to be seen in its entire thickness, but time did not permit me to visit the localities. Hicks, however, records from the beds the same fauna as he obtained from the 'Tremadoc' of Ramsey Island, so that their Arenig age may be safely assumed.

[1] The Trilobites were kindly identified by Mr. Philip Lake.

[2] Gertrude L. Elles, "Some Graptolite Zones in Arenig Rocks": Geol. Mag., 1904, p. 209.

[3] H. H. Thomas, in the *Geology of the South Wales Coal-field*, pt. x (Mem. Geol. Surv.), 1909, p. 10.

The only other area where 'Tremadoc' rocks occur in the St. David's district is at Tremanhire, north-east of Solva. They have been examined recently by Mr. H. H. Thomas and Professor O. T. Jones, who kindly inform me that they consider the rocks to be undoubtedly of Arenig age. They yield an *Oggygia*, probably *O. selwyni*.

V.—What is Laterite?

By L. Leigh Fermor, A.R.S.M., D.Sc., F.G.S., Geological Survey of India.

(*Concluded from the November Number, p. 516.*)

Laterite a stratigraphical as well as a petrographical term.—In this paper I have urged the advisability of applying the terms *laterite*, *lithomargic* and *quartzose laterite*, *lateritic lithomarge*, etc., to certain rocks, all of which some geologists would include under the term *laterite*. This restriction of the use of the word *laterite* is advocated in the petrographical sense. Besides being used as a rock name, this word is also applied as the name of a geological formation in India, ranging from Tertiary, through Pleistocene, into recent times,[1] for probably in some parts of India, as in other parts of the tropics, laterite is still in process of formation. As the name of a formation, the term *laterite* comprises, not only substances that petrographically are true laterite, but also lithomargic and quartzose laterites, lateritic lithomarges, and lithomarges that are practically free from lateritic constituents, not to mention various laterite-cemented detrital rocks. Consequently, in mapping geologically in India it is necessary to include as laterite many rocks that petrographically are not laterite.

The parallel to such a twofold use of the word is easy to find. The Charnockite Series includes members that are not charnockite. The Bengal Gneiss is the name of a geological formation containing not only gneisses, but also limestones, dolomites, and mica-schists. No one wishes to call a piece of limestone from this formation "a piece of Bengal gneiss". Similar examples occur in the stratigraphical nomenclature of most countries.

It is probably failure to notice this twofold application of Buchanan's original term in Indian geology that has led geologists in other parts of the world to a comprehensive use of the term petrographically, as well as stratigraphically. There can be no objection to engineers using the term in a wide sense, for although some of the substances designated *laterite* by them will not be laterites in the petrographic sense, yet they will in most cases belong to lateritic formations.

IV. The Application of the term Bauxite.

The question whether the word *bauxite* should be retained as the name of a definite mineral or not is not difficult to answer if one appeals to the historical side of the subject. P. Berthier,[2] in 1821, described a supposed iron-ore (*minerai de fer*) from Beaux near Arles in Provence, which he had analysed and found to be "composé

[1] *Manual of the Geology of India*, 1893, p. 369. On p. 385 the use of this word as a lithological and a chronological term is discussed, and the former use preferred.

[2] Ann. des Mines, vi, pp. 531–4.

d'hydrate d'alumine, mélangé d'oxide rouge de fer", containing 52·0 per cent of Al_2O_3, 20·4 per cent of H_2O, and 27·6 per cent of Fe_2O_3, with a trace of Cr_2O_3. Berthier says that the iron is evidently present in the mineral in the anhydrous condition and in "l'état de mélange", and that "le minéral pur" would be composed of 72 per cent of Al_2O_3 and 28 per cent of H_2O, corresponding nearly to $Al_2O_3 . 2\,H_2O$. He applies the terms *minerai*, 'ore,' and *minéral*, 'mineral,' indiscriminately to his specimen, and as he proposes no name for the substance it is difficult to say whether he regarded it as a definite mineral, as the construction of a definite formula would seem to indicate.

A. Dufrénoy, on p. 347 of vol. ii of his *Traité de Minéralogie* (1845), refers to the substance analysed by Berthier, and says "Elle ne peut être regardée comme une espèce minérale". But in the index to vol. iii of this work, published in 1847, the following entry occurs (p. 799): "Beauxite, *nom donné* à l'alumine hydratée de Beaux," the reference being to vol. ii.

St. Claire Deville[1] in 1861 contributes a paper entitled "De la Présence du Vanadium dans un Minerai Alumineux du Midi de la France". He heads his first chapter thus: "Minerais Alumineux ou Bauxite," showing that he regarded *bauxite* (the correct spelling) as an *aluminous ore*; further, he mentions Berthier as the originator of the name, as follows: "ce minerai particulier que M. Berthier a appelé la *bauxite*." On p. 321 Deville gives a number of analyses, one of which shows 48·8 per cent of Fe_2O_3 and only 33·2 per cent of Al_2O_3, indicating an extension of the term *bauxite* to include very ferruginous varieties. The amount of water present in these analyses is generally insufficient for the formation of $Al_2O_3 . 2\,H_2O$. The presence of TiO_2 is shown. On p. 324 the term *bauxite* is applied to an iron-ore from Paradou in Provence containing 60 per cent of Fe_2O_3 and 18 per cent of Al_2O_3 and TiO_2.

Sufficient is quoted above to show that the name *bauxite* was not given to a definite mineral, but to an impure aluminium-ore of very variable composition, and that consequently its application has, really, always been to a rock and not to a mineral. The assumption, perhaps only intended as a suggestion, of the existence of the definite compound $Al_2O_3 . 2\,H_2O$, first made by Berthier, and adopted by Dana, is not apparently justifiable, and it seems that bauxite must be regarded as a true rock, and the term *bauxite* must consequently be available to petrographers for use in this sense. The matter is summed up admirably by Professor Lacroix on p. 342 of vol. iii of his *Minéralogie de la France et de ses Colonies* (1901). Lacroix says that the examination of a large number of analyses shows that bauxite, where it contains the minimum of impurities, approaches nearer to the composition of diaspore than of any other mineral, and that bauxite is to be regarded as constituted of various colloid hydroxides of aluminium, mixed with the corresponding hydroxides of iron, and with various impurities, clay, quartz, sand, etc. "C'est en réalité une véritable roche."[2]

[1] Ann. Chim. Phy., ser. III, lxi, pp. 309–42.

[2] Since the above was written we have received in the library of the Geological Survey of India, vol. cxlviii of the *Comptes Rendus* (1909), in which there are

The term *bauxite* was, as is seen above, extended by Deville to rocks very high in Fe_2O_3, and it has often been used in France to correspond with rocks ranging from the most aluminous to the most ferruginous laterites of India. Mr. Scrivenor's contention, then, would seem to be upheld, namely, that we can replace the term *laterite* by the word *bauxite*. But it should be remembered that the term *laterite* dates from 1807, and the term *bauxite* only from 1847. The French mineralogists have, therefore, used the word *bauxite* for a substance for which a name already existed, and therefore if any change were necessary we should call upon our French colleagues to drop the term *bauxite* and to substitute for it the term *laterite*. Such a course would be absurd, and I think the most desirable procedure is to restrict the term *bauxite* to those varieties of *laterite* sufficiently rich in alumina to be used as aluminium-ores. If the rock contains more Fe_2O_3 than Al_2O_3, it is not likely to be used as an aluminium-ore, and therefore I think the term *bauxite* might be restricted to those *laterites* that contain at least as much Al_2O_3 as Fe_2O_3.

Lacroix follows a somewhat similar course. He says (p. 346) that he reserves the name *bauxite* (*sensu stricto*) for rocks of the type of those of Provence, and to the very aluminous and often pisolitic patches (*accidents*) in *laterite*, whilst he uses the word *laterite* in its customary sense—defined earlier (p. 345) as the red rock that is formed in tropical climes by the decomposition in situ of the most diverse rocks, e.g. granites, diorites, basalts, gneiss, etc.—and applied it in addition to rocks of the same composition, such as the bauxites of the Puy-de-Dôme (alteration of gneiss) and of Hesse (alteration of basalts), of which one can prove the formation in situ at the expense of silicate rocks (*roches silicatées*).

In closing this section it is interesting to notice that Mr. Scrivenor, whilst quoting Professor Lacroix to the effect that *bauxite* is a rock and not a mineral, has apparently overlooked the same author's distinction between the terms *bauxite* and *laterite*, which conflicts with his (Scrivenor's) suggestion that the term *laterite* should be replaced by the term *bauxite*.

V. The Lateritic Earths of British Guiana.

I will conclude this paper with a brief consideration of the surface decomposition rocks of British Guiana, as discussed in this Magazine (already summarized), and which have given rise to this communication. I will take Professor Harrison's paper entitled "The Residual Earths

two notes, on pp. 936–8 and 1115–18 respectively, by M. H. Arsandaux, "Sur la composition de la bauxite." In the earlier note it is shown by treating certain French bauxites with concentrated H Cl, and then attacking the insoluble residue with concentrated H_2SO_4, that nearly all the alumina is present as $Al_2O_3 . H_2O$, thus corresponding, although the rocks were found in thin sections to be completely isotropic, to the composition of diaspore. The iron is shown to be present as anhydrous Fe_2O_3. The titania is believed to be present as meta-titanic acid, $TiO_2 . H_2O$, and the small quantities of silica as $2H_2O . Al_2O_3 . 2SiO_2$ (the kaolin or lithomarge formula). The second note deals with the more siliceous bauxites (also completely isotropic), and indicates the existence of every gradation between clay and $Al_2O_3 . H_2O$.

of British Guiana commonly termed 'Laterite'", in the GEOLOGICAL MAGAZINE, 1910, pp. 439, 488, and 553.

On p. 441 is given a table of analyses of "laterite soils". Only one of those soils contains less than 50 per cent of "gravel + quartz sand + clay, silica, and insoluble silicates", namely, the soil derived from hornblende-schist at Maburima. This might be termed *argillaceous laterite*, the adjective applicable depending on the exact nature of the 29·16 per cent representing the third item above. Some of the other soils, namely, those containing considerable amounts of oxides of iron and aluminium, such as Nos. 1, 4, 9, 12, and 13, might be termed *lateritic clay*, *soil*, or *sand*, whilst the majority of the others would be best designated clay, gravel, sand, or soil, without the dignity of the adjective 'lateritic'.

In Table II, on p. 444, showing decomposition products from Issorora Hill, the *red lateritic earth* is correctly named. The *concretionary ironstones* and *ironstone pisolites* are also correctly named, but might be regarded as varieties of laterite, being the results, in fact, of the segregation of the lateritic constituents of the *lateritic earth*.

In Table V, on p. 447, three rocks are boldly classed as laterites. To none of them is the name, in my opinion, applicable. The earths from Tumatumari, Omai Falls, and Mazaruni contain 47·3, 45·8, and 39·9 per cent of lateritic constituents respectively, and should, by preference, be termed *lateritic earths*.

The sericitic earth represented by Table VII on p. 449 contains 37·6 per cent of lateritic constituents and might also be termed *lateritic*. The three samples of *bauxite* or *laterite* shown in Table IX on p. 451 are correctly so named, and are in fact the only "residual earths" noticed in Harrison's paper to which the term can be correctly applied, with the exception, perhaps, of the segregations of concretionary ironstone or lateritic iron-ore in the red lateritic earth of Issorora Hill.

But these three samples which I regard as the only true laterites described by Harrison, represent, according to this author (p. 488),

> "the extreme of the formation of laterite, where the igneous rock, in place of weathering to a mixture of quartz, of kaolinite, of bauxite, and of the oxides and hydrates of iron, changes almost completely to quartz and to hydrates of alumina and the oxides and hydrates of iron."

Further, he says (p. 489) that the foregoing examples, that is to say, all the various soils, earths, and laterites noticed above,

> "represent the types of the residual deposits in situ in British Guiana, which I have regarded as and termed laterite."

And in Table X he gives the mean proximate composition of the British Guiana lateritic earths examined by him as follows:—

Quartz	24
Iron-ores (including pisolites)	32
Kaolin, Sericite, and other felspathic debris, etc.	24
Bauxite	20
	100

This corresponds to 52 per cent of lateritic material and 48 per cent

of non-lateritic material, and, although just within the limits for laterite, yet judging from Professor Harrison's descriptions and the composition of the earths taken individually, I think he would be more in conformity with usage were he to use the term *lateritic earths* when speaking of these substances as a whole, and not to use the terms 'laterite' and 'lateritic earth' as equivalent and interchangeable.

On p. 494 analyses are given of two pisolitic 'laterites' which evidently deceived Professor Harrison as much as the similar Indian pisolitic lithomarge of which the analysis is given on p. 510 deceived Maclaren and me; for the analyses quoted show that instead of obtaining rocks to correspond to Du Bois' pisolitic iron-ore and oolitic bauxite as he intended, Harrison has collected merely a ferruginous kaolin in one case, and a less impure kaolin or lithomarge in the other.

The Laterite of Surinam.—On p. 558, Table XXIV, three technical analyses of laterites from Surinam are quoted from Du Bois' monograph. These show respectively 91·4, 84·1, and 94·5 per cent of hydrated oxides of alumina and iron, and two of them are nearly as pure as some of the best Indian laterites.

On the bottom of p. 558 Harrison refers, in the following words, to the only laterite he has seen in Surinam:—

> "Here there is a gradual change of the decomposing schist into its laterite, the change extending to considerable depths in the schist. The lateritic earth, covered in places by concretionary masses of ironstone, reminded me of Logan's account of the ferruginous and silico-ferruginous rocks and laterite of Singapore . . . and of Mr. Scrivenor's description of the laterite of the Malay Peninsula . . ."

Judging from the description this Surinam rock is not a residual deposit, but a metasomatic replacement deposit, for which I have offered the term *lateritoid*, which I have already remarked seems applicable to Mr. Scrivenor's laterite.

Professor Harrison is, however, only following Du Bois[1] in his wide extension of the term *laterite*, for the latter in his paper on the laterite of Surinam divides his laterites into—

(1) Primary (Eluviale) laterite, or laterite rich in silica, and
(2) Secondary (Alluviale) laterite from laterite detritus, or laterite rich in aluminium hydroxide.

But Du Bois has also, I think, extended the term too widely, and although some of the analyses given in his paper represent rocks that can fairly be designated laterite, the remainder cannot, in my opinion, be so classed; for example, the decomposition products of diabase given on p. 24 of Du Bois' paper, which are merely *partially altered diabase*. The analyses on p. 28 represent substances that contain some 65 per cent of quartz and clay, and might be called *lateritic sand* or *earth*, but might also be allowed the names *alluvial* or *secondary laterite*, given to them by Du Bois. The analyses given on p. 37, however, represent *true laterites*. These are the ones quoted by Harrison.

From the foregoing it will be seen that if one accepts the ideas as to what is a true laterite put forward in this paper, it becomes

[1] Tschermak's *Mittheilungen*, 1903, p. 48.

apparent, judging from the work of Harrison and Du Bois, that the term has been too widely used in the Guianas.[1]

Hardening properties of laterite.—Professor Harrison's paper bristles with other controversial points, but this communication has already grown to an inordinate length, and consequently I will refer to one other point only. It is a mistake to think that all laterites will behave in the way that the laterite first described by Buchanan behaved, namely, that they will be found to be soft when first quarried and will harden on exposure to the air, except to the small extent that most rocks harden owing to evaporation of contained moisture. In my experience certain varieties of laterite (e.g. high-level laterites of Balaghat) that both in chemical composition and in physical appearance are true laterites, and to which Buchanan would undoubtedly have applied the term, are not found to be markedly softer when quarried than after exposure to the air. Further, Harrison on p. 493 of his paper describes a clay-like mass that hardens on exposure, and which analysis shows to contain 50·3 per cent of felspar and 22·1 per cent of kaolinite, with only 24·5 per cent of lateritic constituents.[2]

Consequently, to appeal to this setting property of a rock, in

[1] The same remark probably applies to many another tropical area in which *lateritic rocks* occur. Thus, I have quoted with approval the work of M. Arsandaux on the French bauxites (see note, p. 561). But I do not agree with his two later notes (pp. 682–5 and 1082–4 respectively, of C.R., vol. cxlix, 1909), in which he gives and discusses analyses of 'laterites' from the *French Congo* and the *Soudan*. As before, he extracts the Fe_2O_3, and in this case the free Al_2O_3 as well, with concentrated H Cl, and decomposes the insoluble residue by means of concentrated H_2SO_4. To the former fraction (my *lateritic constituents*) he pays no attention, but shows that the portion insoluble in H Cl, which amounts to 68–99 per cent of the whole rock, varies in composition *from* micaceous alumino-potassic silicates allied to muscovite *to* kaolin practically free from alkalies. Most of these rocks have been formed in situ by the weathering of crystalline rocks (granites, schists, etc.), and it is evident from the author's analyses and descriptions that his so-called laterites are really *clays* containing a certain, usually small, proportion of lateritic material. The very uppermost crust may be laterite, properly so called, but no analyses of this are given.

Reference may also be made to the analyses of 'laterites' (derived from basic rocks—diabase and ophite), from *French Guinea*, by J. Chateaud and P. Lemoine (C.R., vol. cxlvi, pp. 239–42, 1908). The analyses show, in most cases, a considerable amount of silica, but it is apparently (p. 241) almost entirely in the free condition. On this assumption, No. 11, with only 5·52 per cent of SiO_2, is a *true laterite*; Nos. 136, 179, 180, 181, and 185, containing 12 to 28 per cent of SiO_2, are *quartzose laterites*, whilst No. 195 (derived from phyllite) with 62·30 per cent of SiO_2 cannot be regarded as a laterite at all. That the authors do not regard these rocks as completely formed laterites (my true laterites) is indicated by the following passage: "La *silice* est presque complètement rendue libre; les $\frac{3}{4}$ environ ont été entraînés; le reste, qui aurait probablement disparu si la latéritisation avait été complète, ne joue qu'un rôle insignificant et est, en majeure partie, à l'état de silice libre." A diagram illustrates the chemical losses involved in the formation of laterite No. 11 from diabase No. 2, on the assumption of constant TiO_2.

[2] W. T. Blanford, in his account of the Laterite of Orissa (Mem. Geol. Surv. India, i, p. 283, 1859), referring to the lithomarge underlying the laterite, says that on exposure it becomes hard like laterite.

deciding whether or not it is a laterite, is unsatisfactory, unless considered in conjunction with the chemical composition.

VI. Summary.

1. The term *laterite* is used in two ways, namely, *stratigraphically* as the name of a geological formation, and *petrographically* as the name of a tropical superficial rock. This discussion relates only to the use of the term as a rock name.

2. *Laterite* (or rather some varieties of it) is formed by a process, the *modus operandi* of which is not discussed here, by which certain rocks undergo superficial decomposition, with the removal in solution of combined silica, lime, magnesia, soda, and potash, and with the residual accumulation, assisted, no doubt, by capillary action, metasomatic replacement, and segregative changes of a hydrated mixture of oxides of iron, aluminium, and titanium, with, more rarely, manganese. These oxides and hydroxides of iron, aluminium, titanium, and manganese are designated the *lateritic constituents*.

3. This residual rock is *true laterite*, and the presence of any considerable proportion (>10 per cent) of non-lateritic constituents requires expression in the name, as it always indicates want of completion in the process of lateritization. True laterite contains, then, 90 to 100 per cent of lateritic constituents.

4. There is often a gradation in composition between true laterite as defined above and lithomarge, which is taken as the amorphous compound of composition, $2\,H_2O\,.\,Al_2O_3\,.\,2\,SiO_2$ corresponding to the crystalline mineral kaolinite of the same composition. For the rocks intermediate between laterite and lithomarge the terms *lithomargic laterite* and *lateritic lithomarge* are available, the former being applied to forms containing 50 to 90 per cent of lateritic constituents, and the latter to forms containing only 25 to 50 per cent of lateritic constituents.

5. The presence of any considerable amount of quartz, either residual or secondary (this form has not, so far as I am aware, yet been noticed in Indian laterites), should be indicated by terming the rock a *quartzose laterite*, unless the amount of quartz and other non-lateritic constituents exceed 50 per cent, when the word *laterite* should appear only in the adjectival form, as in paragraph 4.

6. Many rocks to which the term *laterite* has been applied would be more aptly termed *soils*, *earths*, *clays*, and *sands*, with (>25 per cent) or without (<25 per cent of lateritic constituents) the attributive *lateritic*.

7. *Varieties* of the rock defined as true laterite are those in which one of the constituents is present in relatively large amounts, namely, the highly aluminous variety, *bauxite*, the highly ferruginous variety, *lateritic iron-ore*, and the highly manganiferous variety, *lateritic manganese-ore*. From this it follows that alumina cannot be regarded as an essential constituent of laterite, although it is usually present in smaller or larger quantity.

8. The property of *hardening on exposure* to the air is characteristic of many varieties of laterite, but it is not an essential property; for some laterites do not exhibit it, whilst cases have been recorded of

rocks that show this property and yet cannot possibly be termed laterite, although they probably contain a certain quantity of hydroxides of iron and aluminium, to the dehydration of which the setting of laterite is usually ascribed.

9. For any rocks (such as some of the *pisolitic limonites*), associated with the laterite formation, that have probably been formed by chemical deposition in lakes or bogs the name *lake laterite* is suggested. This is regarded as an unimportant variety of laterite.

10. Certain lateritic rocks that have been formed by the metasomatic replacement at the outcrops of a variety of rocks, and which cannot be regarded as residual products of the decomposition of the underlying rocks, have been designated *lateritoid*. Such rocks can usually be recognized by their preserving unaltered or but partly altered fragments of the underlying rocks, and of retaining signs of the original bedding-planes of the rocks they have replaced. They have hitherto always been found on the upturned outcrops of the quartzites and argillaceous schists and phyllites of the Dharwar formation, and usually take the form of iron-ore or manganese-ore, alumina not being an abundant constituent of the lateritoids.

11. Rocks formed by the accumulation of detritus from masses of chemically-formed laterite (or of lateritoid) either alone, or mixed with extraneous materials, such as fragments of quartz or gneiss, may be termed *detrital laterites*, as an alternative to which the term *lateritite* is suggested.

12. Most of the so-called laterites of the Guianas as described by Harrison and Du Bois are not true laterites unqualified, but are either *quartzose* or *lithomargic laterites*, or *lateritic earths*. Many of them are detrital rocks, sometimes rich enough in lateritic material to be called *detrital laterite* or *lateritite*. True laterites do, however, also occur.

13. The classification of laterites and associated rocks put forward in this paper is, of course, of a more or less tentative nature, and although it is believed to be a workable system of nomenclature, yet future work will doubtless show the desirability of various modifications and amplifications.

REVIEWS.

I.—The Ice Age in North America and its Bearings upon the Antiquity of Man. By G. Frederick Wright, D.D., LL.D. Fifth Edition. 8vo; pp. xxi, 763, with 10 plates, 3 maps, and 196 text-illustrations. Oberlin (Ohio), Bibliotheca Sacra Company; London, Charles Higham and Son; 1911. Price 20*s.* net.

A NEW edition of Dr. Wright's great work will be widely appreciated by students and teachers, giving as it does such a clear and comprehensive view of the grander features in Glacial geology that are so well exhibited in North America. Although, as the author remarks, later investigations have not seriously affected the main theories adopted in 1889, when the first edition of his work was published, yet there have been further destructive criticisms of

Croll's views on the cause of the Glacial Period and of astronomical calculations respecting Glacial chronology. On the other hand, the views on the former extent and action of land-ice, enunciated by Agassiz in 1840, have gained almost universal adherence, and there remain very few geologists whose opinions can be said to be seventy years or more behind the times.

In the preliminary account of existing glaciers and ice-sheets a good deal of new material has naturally been gathered from researches in Greenland, Central Asia, and the Antarctic regions. In Alaska, again, interesting instances have been recorded of the advance and retreat of the glaciers bordering Yakutat and Glacier Bays. In the former bay a remarkable advance in the ice has been attributed by Professor Tarr to the effect of an earthquake in 1899. By that disturbance a portion of the coast was elevated 47 feet, and thereby large quantities of snow were probably shaken from the more elevated peaks upon the head of the glaciers. Interesting, too, are the accounts of the Muir Glacier, the ice from which nearly filled Glacier Bay a century ago. Owing to the present recession a buried forest with many upright stumps of trees has been partially exposed beneath sand and gravel, and the author remarks, "There can be no doubt that, after the accumulation of sand burying the forest, the glacier advanced for a great distance over it, attaining a thickness at that point of two or three thousand feet." This leads to some remarks on the capacity of ice to move over such deposits without disturbing them. No doubt a great deal depends on the form and composition of the land-surface over which the ice passed, whether smooth or irregular, evidences of drag and disturbance being more often seen where the surface was uneven or where boulder-clay rests on mixed strata of clay and gravel.

Greenland, regarded as an island of continental proportions and the most important accessible field for glacial observations, is almost wholly covered by an ice-sheet, having an area of about 575,000 square miles, a length of 1,500 miles, and a width of 700 miles. The author, however, remarks that "The absence of glacial phenomena north of the range of mountains which forms the southern boundary of Alaska, and over the adjacent plains of Northern Siberia, completely disproves the once current theory that the glacial period was characterized by a vast ice-cap extending in all directions from the pole".

The Ice Age in North America, as in Europe, "began and ended in a great number of local glaciers which became confluent and continuous only during the middle of the period." The area covered by the ice at its maximum extension is shown in fig. 62, and other maps indicate in more detail the southern limit of the ice-sheet and drift.

On the coast of Maine the ice is reckoned to have been more than 1,500 feet thick, while over the central portions of the glaciated area in North America it may have been as much as three miles. This latter calculation is based on the evidence of movement of ice from Labrador to the southern part of Illinois, a distance of about 1,600 miles. It is estimated that there must have been an average slope of 10 feet to the mile, and that the movement must have been produced mainly by the simple accumulation of ice.

The extreme glacial margin is often, but not always, marked by a distinct terminal moraine, with a certain amount of intra-moraine and extra-morainic drifts. The last-named drifts include what is termed the "fringe" or "attenuated border" of sporadic or modified glacial deposits, which may extend about 20 or 30 miles south of the glacial margin; and they comprise coarse 'over-wash' gravel and boulders formed by marginal drainage. As the author remarks, "it has been questioned by some whether the larger part of the grist of the glacier has not been thus transported far beyond the extreme limits reached by the ice itself," and by subglacial streams "surcharged and milky-white with sediment". The terminal moraines form marked features, rising in places from 150 to 300 feet above the general level of the country, accompanied by huge boulders and by kettle-holes and the small lakelets enclosed by them. Other moraines have been attributed by some geologists to a "second Glacial epoch", but they are more appropriately termed "moraines of retrocession"; and there are also minor local moraines.

It is estimated that not less than one million square miles of territory in North America "is covered with an average depth of fifty feet of glacial débris, forming the most permanently productive part of the continent".

Various stages in the Glacial Period, indicating advance and retreat of the ice, have been described more or less locally under the names Sub-Aftonian, Aftonian, Kansan, Iowan, Illinoisan, and Wisconsin (the latest). In the earlier three stages, the deposits are more oxidized—a feature attributed to their antiquity; the materials having been the first taken up by the advancing ice from the already decomposed and oxidized soils and subsoils.

Certain 'forest-beds' and peaty deposits have been taken to mark a second Glacial epoch or one or more Interglacial periods. The author, however, remarks that while in places these accumulations have glacial drift both under and over them, they may belong to various times of recession and advance of the ice, and may in fact have originated "in front of the margin of the slowly retreating ice if only there were comparatively brief periods of readvance". Moreover, the buried vegetable deposits "do not mark a warm climate, but a climate much colder than the present", and "it may well be questioned whether an interval of two or three centuries would not suffice for the accumulation of the peat described". Most of the facts relating to the Ice Age support "the theory of but one epoch with the natural oscillations accompanying the retreat of so vast an ice-front".

The influence on drainage systems is not the least fascinating of subjects connected with the Glacial Period. The infilling of pre-Glacial valleys so diverted the lines of superficial drainage that many streams took courses over rocky beds at levels higher than they formerly occupied, and the glaciated region became one of waterfalls. The falls of Niagara are an example. Before the Ice Age nearly all the streams in the eastern United States occupied deeper channels than they do now. "There were then probably no Great Lakes, and few, if any, waterfalls, as there are now no lakes and waterfalls south of the glaciated region. All the rivers had cut their channels down so

low that they drained to the bottom any lakes that may have once existed." The effect of the icy barrier in damming up streams and rivers and forming huge temporary lakes and smaller lakelets is well told in these pages from the observations of numerous geologists, including the author; while in other instances the torrents of glacial water that were poured into the Mississippi and Ohio were of great magnitude, and there are indications that glacial floods rose in the Lower Missouri to a height of 200 feet or more.

Dr. Warren Upham contributes an account of "The Glacial Lake Agassiz", and particulars of Lake Allegheny are printed from an unpublished report of Professor E. H. Williams.

Of the erosive and transporting power of moving ice much information is given; and the view advocated by Newberry that glacial ice "was a prominent agent in the formation of the Great Lakes" is sympathetically treated by the author.

We have given, mostly in his own words, some account of the principal subjects dealt with in this volume: with these we should also mention the influence of the Glacial Period on the distribution of plants and animals. To the two chapters on "The Cause of the Glacial Period" some "Supplemental Notes" are contributed by Dr. Upham, who deals with the effects of great epeirogenic elevations, and with the views of Messrs. Chamberlin and Salisbury on the meteorological effects of the depletion of atmospheric carbon dioxide by reason of the increased area of land and the increased carbonation and oxidation of rocks. Winds and ocean currents are naturally regarded as important factors in the Glacial Period, and reference might have been made to Mr. F. W. Harmer's paper on "The Influence of the Winds upon Climate during the Pleistocene Epoch" (Q.J.G.S., lvii, p. 405, 1901). With regard to the date of the Glacial Period, the author is disposed to support a much lower estimate for the duration of the Ice Age than the 200,000 years he suggested in 1908 (Q.J.G.S., lxiv, p. 149); and he considers that the period may have ended about 10,000 years ago. Evidence is given of the presence of remains of man in the early stages of the Glacial epoch and possibly in Pliocene deposits.

II.—Characteristics of Existing Glaciers. By William Herbert Hobbs, Professor of Geology in the University of Michigan. 8vo; pp. xxiv, 301, with 34 plates and 140 text-illustrations. New York: The Macmillan Co., 1911. Price 13*s.* 6*d.* net.

IN this work the general knowledge of the movements of ice and its influence in shaping many features of the earth's surface is ably expounded and admirably illustrated.

The work is divided into three parts, dealing with Mountain, Arctic, and Antarctic Glaciers; and the author dwells particularly on the distinctions, not only in size, but in origin, movements, and influence on the earth's surface, between the large continental glaciers or ice-sheets and the Alpine or mountain glaciers. As he remarks, the continental ice assumes a form the visible surface of which is largely independent of the rocky foundation on which it rests, while mountain

glaciers are moulded with reference to the irregularities of their beds. In the former "no portion of the lithosphere is exposed above its higher levels. The glaciers of mountains, on the contrary, always have rock exposed above their highest levels". There are, however, small ice-cap or plateau glaciers, as in Norway and Iceland, which to some extent are transitional between the larger ice-sheets and the mountain glaciers, though more closely allied to the former because they rest on a comparatively flat foundation. In the ice-covered archipelago of Franz Josef Land the islands are almost completely snow-capped by *névé* of low density rather than by compact glacier ice, while the group of islands known as Spitzbergen exhibits inland ice, small ice-caps, and true mountain glaciers. In the references to this region (p. 111) the name of Professor Garwood should have been mentioned.

In dealing with mountain glaciers the author commences with a discussion on the origin of cirques, that are so characteristic of mountains which are or have been occupied by glaciers. In explaining their origin he supports the views of Messrs. W. D. Johnson and F. E. Matthes. Snow-banks were formed on shallow depressions of steep slopes, and by a process of 'nivation', due to frost and melting snow, rock-material was broken up and the original depression deepened. Ultimately the snow-banks assumed the functions of glaciers, and removed blocks of rock disintegrated from the walls of the cirques, which in form were at first nearly circular.

This subject is dealt with in considerable detail and is well illustrated, and it leads on to descriptions with explanations of the higher rock-features of the 'Fretted Upland', where we find various types of ridges, needles, etc. Portion of a hill-shaded map of the country between Bethesda and Llanrwst is reproduced to illustrate a 'karling' or high district dissected by cirques. Some reference is made to the influence of a glacial cover in protecting its base from ordinary weathering processes, but the author is hardly justified in speaking (in his preface) of a *school of British geologists* "which holds that the denudational effect of glacier ice is negative, because it protects the basement from the process of weathering". Various types of mountain glaciers dependent on the amount of snow supplied, or 'alimentation', are described and illustrated; and the excavation of U-shaped and hanging valleys is attributed to the widening and deepening accomplished by the ice through combined abrading and plucking processes. Attention is given to the problems of glacial sculpture in Scandinavia and other high latitudes, to the fjords or deep and now partially submerged U-valleys, that were occupied by glacier streams, the courses of which, initiated by pre-existing fractures, may also have been guided by the work of earlier rivers.

That "the Pleistocene glaciation consisted of some four distinct glacial cycles which were characterized by relatively mild climatic conditions", is regarded by the author as well recognized, though he should have added, "by some distinguished glacialists." A short account of the glacial features due mainly to deposition concludes Part I.

In Parts II and III we have descriptions of the more extensive

tracts of ice in Arctic and Antarctic regions, and the physical features of the two areas are contrasted. In the one we have a polar sea surrounded by an irregular chain of land-masses, in the other a high continent massed near the South Pole. Excellent views are reproduced of the glacial features in Greenland, after Nathorst, Chamberlin, Trolle, and others. Accounts are given of the wind-drifted snow in this 'Arctic Sahara', of the various streams superglacial, englacial, and subglacial, of ice-dammed lakes, of 'submarine wells' or whirlpools of fresh water that rise at the heads of some of the fjords, and of the methods of discharge of bergs from the ice-front.

Finally, the volume includes good descriptions concerning what is known of the Antarctic Continent and its sea-ice girdle, of the marginal shelf-ice or so-called 'barrier' ice, and of the great inland ice-sheet, subjects well illustrated by views after von Drygalski, Scott, Shackleton, and others.

III.—Rock Minerals: their Chemical and Physical Characters and their Determination in Thin Sections. By Joseph P. Iddings. Second Edition. 8vo; pp. xiii + 617, 500 figures, and one coloured plate; cloth. New York, John Wiley and Sons; London, Chapman & Hall, Ltd.; 1911. Price $5.

IT is a sign of the great utility and consequent demand for this valuable technical treatise that within five years it has been necessary to issue a second edition. This edition differs from the first mainly in its greater bulk, a feature necessitated by the remarkable progress made in various departments of mineralogical science. The introductory portion, containing a general account of physical and optical characters, remains practically without change; but a very clear and not too laboured account of pleochroic haloes has been added. In this are summarized the results obtained by Mügge, Joly, and Fletcher, and a table of measurements by the two latter authors is given.

In the section devoted to the description of minerals important additions have been made with respect to nineteen species and seven groups not treated of in the previous issue of this work. Among the rare and recently discovered minerals concerning which particulars are given may be noted carnegieite and rhönite. The groups referred to are designated respectively by the names of the minerals melanocerite, columbite, samarskite, æschenite, aragonite, barite, and triphyllite. The systematization of hitherto unassociated details given therein will undoubtedly be of considerable value to students. In the interests of terminological accuracy it might have been well in the description of minerals to substitute the word alstonite for bromlite, the latter designation owing its origin to a misspelling of the name of the locality Brownley Hill.

An excellent birefringence diagram has been added to the tables and plate of interference colours at the end of the book. There can be no doubt that this volume, brought up to date as it is with scrupulous accuracy and attention to the requirements of students of petrography, cannot fail fully to maintain its high position among the premier treatises on mineralogical science.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 8, 1911.—Professor W. W. Watts, Sc.D., LL.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Interglacial Gravel Beds of the Isle of Wight and the South of England, and the Conditions of their Formation." By Professor Edward Hull, M.A., LL.D., F.R.S., F.G.S.

The author, after referring to the investigations of previous authors, especially of Mr. Codrington and the officers of the Geological Survey, with which he in the main agrees, points out that the origin and mode of formation of the gravel terraces of the Isle of Wight and the New Forest districts are still open to discussion. He points out that the levels of the higher beds on both sides of the Solent up to about 400 feet indicate the amount of subsidence of the whole area at a time when the stratified gravels, composed mainly of rolled flints, were formed at the margin of the uprising ridges of the Chalk in the post-Glacial epoch, for this part of England. Preceding this was the great uplift indicated by Godwin-Austen, by which the British Isles were joined to the Continent as land. By this uplift the English Channel was laid dry, and along its centre there ran a river from its source about the Straits of Dover to its outlet into the ocean through the Continental Platform. This river-channel is laid down on the Admiralty Charts under the name of 'the Hurd Deep' for a distance of 30 miles of its course, and has been named by the author 'the English Channel River'. The author considers the gravel beds of this district to be the representatives of the High-level Gravels of the Midlands and Cromer, also of the 'Interglacial Gravels' of Cheshire and Lancashire, and the shell-bearing beds of the Denbighshire Hills, and of Moel Tryfaen in Wales, at levels of about 1,200 feet above the sea.

2. "The Gopeng Beds of Kinta (Federated Malay States)." By John Brooke Scrivenor, M.A., F.G.S.

The paper as originally presented was the outcome of field-work done chiefly in 1910; but, as it had to be held over until the November session, an appendix has been added giving additional evidence supporting the author's views and more information about the extent of the Gopeng Beds.

Gopeng is a prosperous mining centre in the Kinta Valley, close to the granite of the main range of the Malay Peninsula. The following is the succession of the rocks:—

Youngest.	The Mesozoic granite, with its modifications and veins.
	Phyllites and quartzites.
	The Gopeng Beds.
Oldest.	Crystalline limestone (Carboniferous or Permo-Carboniferous).

The physical features of the country are described, and it is shown that not only are the Gopeng Beds cut by veins from the granite and altered at the junction with the granite, but they are also faulted down against the limestone, which forms precipitous hills.

The Gopeng Beds, consisting of clays and boulder-clays with some stratified drift, are of glacial origin. This is proved by the inclusion of large boulders in the clay, by the physical condition of the components of the clays and their distribution, and by the striking resemblance of the beds as a whole to Pleistocene glacial detritus.

The nature of the beds is considered to be sufficient proof of glacial origin, but it is admitted that no boulders have been found showing striation due to ice-action, nor has any glaciated rock-surface been found. Such evidence, however, can hardly be expected, because the boulders are all more or less decomposed owing to the great power of the ground-water in removing silica; and, if the limestone ever presented the features of a glaciated surface, it has been so much modified by solution owing to the action of ground-water since then, that all traces of those features must have disappeared. Large unweathered boulders of corundum are present in some of the beds, but their hardness would make the appearance of ice-scratches improbable.

Unfortunately the pale and uniform colouring of the bulk of the clays and boulder-clays makes it hard to obtain photographs showing clearly the resemblance to Pleistocene glacial deposits. A number of photographs is submitted, however, that will, it is hoped, do something towards this. The petrology of the Gopeng Beds is described in detail. The most interesting point revealed is that the ice from which the detritus was derived passed over a stanniferous granite mass, and in consequence the Gopeng Beds carry tin-ore throughout, though sometimes in very small quantities. This tin-ore is an original constituent of the beds, but they have been further enriched by tin-ore derived from the Mesozoic granite at their junction with the granite and in the neighbourhood of veins from the granite that have risen through the limestone.

The faulting in the Gopeng neighbourhood, the general structure of the country, and the age and origin of the Gopeng Beds are discussed in detail. The Gopeng Beds are considered to be the equivalent in time of the Talchir boulder-beds of Orissa; but a petrological similarity is wanting, because the Gopeng Beds were derived from a mass of stanniferous granite, the position of which is at present unknown.

CORRESPONDENCE.

THE CULM-MEASURES OF THE EXETER DISTRICT.

Sir,—In the last number of the Geological Magazine, pp. 495–7, Mr. Arber, when criticizing Mr. F. G. Collins for doing things he has not done, and for omitting others that he has done, has allowed himself to commit a double error.

It is clear from a glance at Mr. Collins's paper[1] that the words Mr. Arber quotes, and to which he objects, are not those of Mr. Collins at all; they relate solely to the fauna which Mr. Crick

[1] Quart. Journ. Geol. Soc., vol. lxxvii, pt. iii, p. 393, 1911.

has so admirably worked out and described in his notes (loc. cit., pp. 399–413).

Mr. Collins has made a good beginning by finding a useful fauna in a difficult area; and by carefully recording the location of the specimens he has laid the foundations of a more detailed knowledge of these rocks in the only possible way. He wisely commits himself to no conclusions at present. When he has done more work on the same lines, with the assistance of his palæontological friends, he may be able to throw some light on the detailed stratigraphy of the area; even if he does not, he will at least have given us something firmer to build upon than those lithological resemblances on which Mr. Arber has to place so much reliance.

C. Davies Sherborn.
J. Allen Howe.

THE ZONAL CLASSIFICATION OF THE TRIMINGHAM CHALK.

Sir,—In his Presidential address this year to the Malacological Society Mr. R. B. Newton quoted my statement in 1908 that "hence the zone of Chalk at Trimingham, lying above the zone of *Belemnitella mucronata*, now divided and defined by me for the first time, requires a name", and inferred from those words that I had forgotten my own proposal in 1906 to establish a zone of *Terebratulina gracilis* and *T. Gisei* for this Chalk. This is a misconstruction, but one to which I have laid myself fairly open by excessive brevity. The facts are that in the original paper of 1908 I stated that my opinion was unaltered (it still is unaltered) that *T. gracilis* and *T. Gisei* were far superior to any other fossil or assemblage of fossils both for defining the zone and for labelling it. My editor said, "You had better leave that out: they will never adopt it," and the statement quoted by Mr. Newton was settled to take its place. It was intended to bear the construction that two opposite views as to the best definition and label of a zone embracing the Chalk of Trimingham being on record, with a detailed account of the palæontology of the numerous divisions of that Chalk, the question is ripe for the final tribunal on such questions, i.e. the consensus of textbook-writers, to which it must be left. It does not follow that either view will succeed.

R. M. Brydone.

November 18, 1911.

OBITUARY.

Deaths are announced, on September 25 of Auguste Michel-Lévy, Director of the Geological Survey of France; on August 6 of Dr Florentino Ameghino, Director of the Museum at Buenos Aires; and on June 5 of Dr. Victor Carl Uhlig, Professor of Geology in the University of Vienna. Suitable Notices will appear later on.

MISCELLANEOUS.

Zoological Address-book.—A second edition of the *Zoologisches Adressbuch* has just been issued for the German Zoological Society by Friedlaender and Sohn for seventeen marks bound. It is a bulky volume of 1110 pages, and from the careful manner in which people in this country are circularized should be found of great service. Universities, Academies, and Societies are included, and the total number of names listed reaches the astonishing total of 17,800, all forming one index at the end. The book will appeal to geologists as well as zoologists, for palæontologists are included. Errors can be found, but what book of this nature is free from them? and such errors are frequently due to the indolence of those receiving the circular in not troubling to return it to the publishers.

Anthrapalæmon Grossarti, Salter, 1861, Rochdale: A Correction.—In the August Number of the Geological Magazine, pp. 361–6, 1911, I published an account of the genus *Anthrapalæmon*, and figured a very beautiful carapace from Sparth, Rochdale, which I stated was obtained by Mr. Fred Holt in 1907. In this I find I was in error, as the specimen in question was found by Mr. H. Howard, of Rochdale, but was sent to me by Mr. Holt. This applies also to the fragmentary specimen of a scorpion, *Eobuthus holti*, Pocock (Mon. Pal. Soc., 1910, p. 14, pl. ii, fig. 2), which I had placed in Mr. Pocock's hands to describe. I regret that I overlooked the fact that both the above specimens were obtained by Mr. Harold Howard. Mr. Howard also mentions that in Mr. Baldwin's article on some "Fossil Myriopods from Rochdale" the writer refers to one *Euphoberia* (Geol. Mag., p. 78, February, 1911) as having been found by Mr. F. Howard: this should read Mr. H. Howard.—H. W.

Our Future Coal Supply.—Mr. McKenna (Home Secretary) on October 30 issued the following statement: "I have seen a report of the address delivered by the President of the British Association, but I observe that the President's forecast of the probable duration of the coal supplies of the country does not take into consideration certain factors which have an important bearing on the question. In the first place, the President's estimate took no account of the large amount of coal in fields unproved at the time of the inquiry of the Royal Commission, nor of the amount of coal lying below the depth of 4,000 feet, which the Commission took to be the present limit of workable coal, but which it may be found possible hereafter to exceed. These two sources the Commission estimated at over 39,000 and 5,000 million tons respectively, or together nearly half as much as the amount of coal estimated to exist in the proved coal-fields. In the second place, the President's estimate was based on the assumption that the output of coal would continue, at any rate for some time, to increase at the same rate as in the past. The Commission, on the other hand, considered that at a time not far distant the rate of increase of output would become slower, to be followed by a period of stationary output, and then a gradual decline. No recommendation

was made by the Royal Commission, who reviewed the whole subject at length as to action with a view to preventing waste in the working and using of coals. The suggestion which Sir W. Ramsay is reported to have made, that Parliament should impose a penalty on wasteful expenditure of energy supplies, would involve an amount of control over the industries of the country which under present conditions it would be impossible for any Government to undertake. The Commission looked forward to the introduction of considerable economies in the future, and I am advised that both in the working and in the using of coal progress is being made in this direction. As regards the question of the export of coal, the Commission reported that the witnesses whom they heard were generally of opinion that 'the maintenance of a large coal export trade is of supreme importance to the country, and essential to the prosperity of the coal-producing districts', and the Commission saw 'no present necessity to restrict artificially the export of coal in order to conserve it for our home supply'."—*Morning Post*, October 31.

Discovery of Flint Implements beneath the Red Crag in Suffolk.—Sir E. Ray Lankester, F.R.S., read a paper before the Royal Society, November 16, 1911, on "The Discovery of a Novel Type of Flint Implements from below the Base of the Red Crag of Suffolk, etc." Flint implements of human manufacture have been discovered by Mr. J. Reid Moir, of Ipswich, in the detritus-beds at the base of the Red Crag in Suffolk and by Mr. W. G. Clarke at the base of the Norwich Crag in Norfolk. These implements are of a novel type—the 'rostro-carinate' or 'eagle's beak'—but include also scrapers, hammers, and large one-sided picks. They do not include any forms resembling the Chellian and Acheuilian ovate implements. The Sub-crag type (rostro-carinate) is essentially compressed from side to side. The Chellian and Acheuilian and Moustierian types are essentially depressed or flattened like a leaf. The race of men who manufactured the Sub-crag flint implements probably lived on the land surface not remote from the sea, during the period of the Coralline Crag, which was characterized by a warmer climate than that of the Red Crag, and may justly be regarded as marking the close of Pliocene conditions in this part of Europe. The land barrier joining Britain to Scandinavia, which had kept the southern part of what is now the North Sea from access of cold northern waters ever since the earliest Tertiary period, disappeared at the beginning of the deposition of the Red Crag.

Errata.

In Dr. Fermor's paper ("What is Laterite?"), table at p. 514, 3rd col., last line but two, *for* mixed *read* veined.

In our notice of Admiral De Horsey's work (p. 524) we have inadvertently printed the title as *Draysoniana*: it should be *Draysonia*.

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